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Assessment of Acidic Deposition and Ozone Effects on Conifer Forests in the San Bernardino Mountains

Standard Operating Procedure Manual: Volume 1

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD
Research Division

ASSESSMENT OF ACIDIC DEPOSITION AND OZONE EFFECTS ON CONIFER FORESTS IN THE SAN BERNARDINO MOUNTAINS

STANDARD OPERATING PROCEDURE MANUAL
VOLUME 1

Contract No. A032-180

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List of Standard Operating Procedures

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1.0 **General Discussion**

This document provides a description of the instruments and datalogging equipment installed at the top of the 94 ft. scaffold tower at plot 2 of the Barton Flats ARB plots to collect meteorological and ozone data. Meteorological observations are logged from the sensors every 2 seconds and output as hourly averages by a Campbell 21X datalogger to a Campbell SM192 storage module. One of the 2 storage modules is always connected to the Campbell. They are swapped every week and one is brought back to the laboratory for downloading. Ozone data is logged every 5 seconds and output as 5 minute averages for later processing to hourly averages. Ozone data is collected for 48 hour periods once a month. Met data is collected continuously from May to mid-November.

1.2 **Measurement Principle**

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

1.4 **Ranges and Typical Values**

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 02	Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1993
RFL 03	Retrieval and Processing of Scaffold Meteorological and Ozone Data
RFL 04	Above and Below Canopy Ozone Data Acquisition
RFL 05	Solar Trailer Operation/Ozone Data Acquisition
DRI 01	Operation and Maintenance of Meteorological Instruments

2.0 **Apparatus and Instrumentation**

1. Climatronics Wind Direction Sensor
2. Vaisala HMP 35A Relative Humidity Sensor
3. Licor Quantum Sensors, 2
4. Type T Thermocouples, 2
5. Metone 014A Wind Speed Sensor
6. Dasibi Model 1008
7. Deep charge 24v batteries, 4
8. Topaz Static Inverter
9. Campbell Scientific 21X Datalogger
10. 21X Datalogger Enclosure Box
11. Technacell 12 Volt, 4.5 AH Battery (Model 1245)
12. Wooden Box 19x13x11 inch, open top
13. Campbell SM192 Storage Modules, 2
14. Campbell SM532 Peripheral Interface
15. Campbell PC208 Datalogger Support Software
16. IBM Compatible Computer with serial and Parallel port(s), at least 640K memory, 5.25 floppy drive, MS-DOS 3.1 or higher.

17. Printer (attached to the PC)
18. Solarex 440 Solar Energizer
19. Amp Meter

3.0 **Calibration Standards**

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

4.0 **Procedures**

4.1 **Start-up**

4.1.1 Instrumentation of the Campbell 21X

The 21X should be fastened into a CSI Enclosure box. Wire the sensors into the Campbell 21X terminals as shown in figure 4.1.1. The Dasibi lead should be connected to the correct 21X terminals but not to the Dasibi. The sensor leads should feed through the opening in the Enclosure box.

Read the manual sections for PC208 software, the SM532 peripheral interface, and the SM192 storage module before installing the software and using the storage modules. Install the PC208 Datalogger support software on the PC. Connect the SM532 Peripheral interface to the PC. Using the software SMCOM establish communication with the storage module. At the main menu containing the options for collecting and storage of data and datalogger programs, choose T -- Terminal emulator. For the next section refer to the section covering SM telecommunications commands in the storage module manual. Use command A to check the status of the storage module. Use the E command to do a noload test of the storage module battery. Replace the battery if a 0 is returned. Use the 100E command to do a loaded test of the battery. Replace the battery if a 0 is returned. Check all storage modules that will be used. Finally reset the storage modules using the 1248K command. This will erase all data in the module, reset the pointers, test ram memory, and set the memory switch to "ring memory." The storage modules are ready for use.

4.1.2 Programming of Campbell 21X

Use the datalogger support software program, EDLOG, to enter the 2 programs TOWER2 and TOWER3. Complete listings of the programs are in appendix A. The program TOWER2 collects hourly meteorological readings, TOWER3 collects hourly meteorological readings and 5 minute ozone readings. It will be necessary to make the following changes to the programs. In TOWER2 and TOWER3 the multiplier in instructions 4 and 5 will need to be replaced with one calculated from the calibration constant that was supplied with the Quantum sensors used. Instruction 4 handles the sensor connected at D5, instruction 5 handles the sensor at D6. See appendix B for an example of the calculation. In TOWER3 instruction 2, the correct multiplier to produce output as ppb from the Dasibi should be input.

Connect the SM532 Peripheral interface to the PC and a storage module. Use the datalogger support software program SMCOM to load the programs TOWER2 and TOWER3 to all of the storage modules.

The sensors (except the Dasibi) should be connected before loading the program to the 21X. For now the Campbell 21X will be running off it's internal alkaline batteries but an external 12v gel cel will be added later. Turn on the 21X. Connect one of the storage modules to the 21X and load TOWER2 following the directions in appendix C. Connect the positive lead from the external gel cel battery to the +12V terminal and the negative to ground and switch the 21X off. Never leave the power switch ON when an external battery is connected. After the program is loaded and the external battery connected, key in * 6 A to check if data is being logged from all the sensors into Input Storage Locations. Use * 5 A to input the correct date and time. After the hour has passed check Final Storage using * 7 A. If everything is working the 21X is ready to be moved to the tower.

Carefully pack the sensors and 21X in a box and transport to the tower. Hoist the box to the top of the tower in the cargo net. Unpack and install sensors on the tower. Install the solar panels and connect to the 21X as in figure 4.1.2. Don't forget to turn the power switch back on before the external battery is disconnected for the solar panel installation. Turn the power switch off after the external battery reconnected. Place the 21X (in its enclosure box) on a platform. Place the wooden box over the 21X and tie a rope around the box and the platform to keep the 21X from sliding off. Keep a small notebook in the 21X enclosure to note maintenance visits, storage module exchanges, and Dasibi installation and removal. Also keep a copy of appendix C, figure 4.1.1, figure 4.1.2, and the blue 21X Prompt Sheet near the 21X.

4.2 Routine Operation

4.2.1 Met Data only

Whenever visiting the tower a check of the datalogger should be made and condition noted in the notebook. Every week the storage module should be exchanged and brought back for a data dump. Do not exchange the storage module on the hour while data is being dumped to it.

4.2.2 Met and Intensive Ozone Data

Ozone data is only collected for a 48 hour period once a month. When it is not being used the Dasibi is removed from the tower. The Dasibi has a 6 ft input tube and was located half way up the tower (approx. mid-canopy). The Dasibi requires 2 24V batteries for each 24 hour period. Attach the batteries to the static inverter and plug the Dasibi into the inverter. Key in * 5 A on the 21X and wait until a few minutes after the hour so the last hour of data will have been saved. Unplug the storage module from the 21X. Connect the "new" storage module. Follow the instructions in appendix C to load TOWER3. Attach the lead to the Dasibi and switch it on. Use * 6 to check Input Storage Location 3. If the number is not reading in the correct units (ppb), use *1 (see the manual for details) to edit the multiplier in instruction 2. The program will be saving ozone data to Final Storage every 5 minutes as well as met data hourly. Use * 7 to check Final Storage for the first few 5 minute averages. If everything is OK close the 21X box. Replace the 24V batteries with fully charged ones after 24 hours.

Leave the same storage module connected for the 48 hours. When the Dasibi is shut down and removed, also exchange the storage module. Follow the instructions in appendix C to reload TOWER2 from the "new" storage module. Check Input Storage and Final Storage to be sure the program has been loaded correctly and is logging only Met data.

4.3 Shut down

At the end of the season, disconnect the storage module. Disconnect the solar panels at the molex connector. Turn the 21X switch ON and disconnect the 21X positive and negative leads from the gel cell battery and amp meter. Turn the 21X switch off. Pack the 21X and sensors in a box and lower in the cargo net. Before storing the 21X for the winter test the storage modules as in section 4.1.1. Arrange for any repairs before next summer.

5.0 Quantification

6.0 Quality Control

7.0 References

Campbell 21X Operator's Manual, Revision 4/89-1.

Appendix A
TOWER2.DOC

Program: Campbell 21X Datalogger program for
Barton Flats 100 ft Tower.
S.Schilling, 5/11/92

Flag Usage: none

Input Channel Usage:

	channel	variable	sensor
Single ended			
	1	Ozone(ppb)	Dasibi
	3	Wind dir	Climatronics WD
	5	temp(C)	Vaisala HMP 35A
	7	RH%	Vaisala HMP 35A
Differential			
	5	solar rad	Licor Quantum 51
	6	solar rad	Licor Quantum 54
	7	temp (C)	TC type T
	8	temp (C)	TC type T
Pulse Channels			
	1	wind speed	Met One Model 014A
Excitation Channels			
	2	wind dir(3.6V)	
	3	Probe temp (4.2V)	

Input Storage locations:
1: panel temp
2: battery voltage
3: Ozone (ppb)
4: TC 1
5: TC 2
6: sol rad 51
7: sol rad 54
8: PRT temp(C)
9: temp holding space
10: RH%
11: wind speed
12: wind dir

Final Storage Locations:
1: array id
2: year
3: julian day
4: hour,minutes
5: Ozone average
6: TC 1 average
7: TC 2 average

```
 8:  SR 51 average
 9:  SR 54 average
10:  probe temp average
11:  RH% average
12:  ws inst sample
13:  wd inst sample
14:  battery sample
15:  ws average (inst 76)
16:  wind vector mag (inst 76)
17:  wind vector dir (inst 76)
18:  wind vector std (inst 76)

Table 1

*      1         Table 1 Programs
 01: 2          Sec. Execution Interval

01:  P17        Panel Temperature
 01: 1          Loc : (PANEL TEMP)

02:  P1         Volt (SE)
 01: 1          Rep
 02: 15         5000 mV fast Range
 03: 1          IN Chan
 04: 3          Loc : (Ozone ppb)
 05: 1          Mult
 06: 0          Offset

03:  P14        Thermocouple Temp (DIFF)
 01: 2          Reps
 02: 2          15 mV slow Range
 03: 7          IN Chan
 04: 1          Type T (Copper-Constantan)
 05: 1          Ref Temp Loc
 06: 4          Loc : (TC 1&2)
 07: 1          Mult
 08: 0          Offset

04:  P2         Volt (DIFF)
 01: 1          Rep
 02: 2          15 mV slow Range
 03: 5          IN Chan
 04: 6          Loc : (SR 51)
 05: 262.8      Mult
 06: 0          Offset

05:  P2         Volt (DIFF)
 01: 1          Rep
 02: 2          15 mV slow Range
```

```
   03: 6         IN Chan
   04: 7         Loc : (SR 54)
   05: 260.73    Mult
   06: 0         Offset

06:  P1          Volt (SE)
   01: 1         Rep
   02: 5         5000 mV slow Range
   03: 7         IN Chan
   04: 10        Loc : (RH%)
   05: .1        Mult
   06: 0         Offset

07:  P5          AC Half Bridge
   01: 1         Rep
   02: 3         50 mV slow Range
   03: 5         IN Chan
   04: 3         Excite all reps w/EXchan 3
   05: 4000      mV Excitation
   06: 9         Loc : (PROBE TEMP)
   07: 1         Mult
   08: 0         Offset

08:  P59         BR Transform Rf[X/(1-X)]
   01: 1         Rep
   02: 9         Loc : (PROBE TEMP)
   03: 100       Multiplier (Rf)

09:  P16         Temperature RTD
   01: 1         Rep
   02: 9         R/Ro Loc
   03: 8         Loc : (PROBE TEMP C)
   04: 1         Mult
   05: 0         Offset

10:  P3          Pulse
   01: 1         Rep
   02: 1         Pulse Input Chan
   03: 22        Switch Closure; Output Hz.
   04: 11        Loc : (WIND SPEED)
   05: .8        Mult
   06: .447      Offset

11:  P4          Excite,Delay,Volt(SE)
   01: 1         Rep
   02: 5         5000 mV slow Range
   03: 3         IN Chan
   04: 2         Excite all reps w/EXchan 2
   05: 2         Delay (units .01sec)
```

```
  06: 3600     mV Excitation
  07: 12       Loc : (WIND DIR)
  08: .1       Mult
  09: 0        Offset

12:  P10       Battery Voltage
  01: 2        Loc : (BATTERY VOLTAGE)

13:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 10       Set flag 0 (output)

14:  P77       Real Time
  01: 1220     Year,Day,Hour-Minute

15:  P71       Average
  01: 6        Reps (Ozone,TC1,TC2,SR51,SR54,PROBE TEMP)
  02: 3        Loc

16:  P71       Average
  01: 1        Rep (RH)
  02: 10       Loc

17:  P70       Sample
  01: 2        Reps (WS, WD)
  02: 11       Loc

18:  P70       Sample
  01: 1        Rep (BATTERY)
  02: 2        Loc

19:  P76       Wind Vector
  01: 1        Rep (output: ws avg,wv mag, wv dir, wv std)
  02: 0        Polar Sensor (speed and direc)
  03: 11       Wind Speed/East Loc
  04: 12       Wind Direction/North Loc

20:  P96       Serial Output (send output to SM)
  01: 30       SM192/716

21:  P         End Table 1


*     2        Table 2 Programs
  01: 0        Sec. Execution Interval

01:  P         End Table 2
```

```
*      3        Table 3 Subroutines

01:   P         End Table 3


*      4        Mode 4 Output Options
  01: 0         (Tape OFF) (Printer OFF)
  02: 0         Printer 300 Baud


*      A        Mode 10 Memory Allocation
  01: 28        Input Locations
  02: 64        Intermediate Locations


*      C        Mode 12 Security (OSX-0)
  01: 00        Security Option
  02: 0000      Security Code
```

Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

```
T:  E:  L:
1:  1:  1:   Loc : (PANEL TEMP)
1: 12:  2:   Loc : (BATTERY VOLTAGE)
1:  2:  3:   Loc : (Ozone ppb)
1:  3:  4:   Loc : (TC 1&2)
1:  4:  6:   Loc : (SR 51)
1:  5:  7:   Loc : (SR 54)
1:  9:  8:   Loc : (PROBE TEMP C)
1:  7:  9:   Loc : (PROBE TEMP)
1:  8:  9:   Loc : (PROBE TEMP)
1:  6: 10:   Loc : (RH%)
1: 10: 11:   Loc : (WIND SPEED)
1: 11: 12:   Loc : (WIND DIR)
```

TOWER3.DOC

Program: Campbell 21X Datalogger program for
Barton Flats 100 ft Tower.
S.Schilling, 5/11/92

Flag Usage: none

Input Channel Usage:

	channel	variable	sensor
Single ended			
	1	Ozone(ppb)	Dasibi
	3	Wind dir	Climatronics WD
	5	temp(C)	Vaisala HMP 35A
	7	RH%	Vaisala HMP 35A
Differential			
	5	solar rad	Licor Quantum 51
	6	solar rad	Licor Quantum 54
	7	temp (C)	TC type T
	8	temp (C)	TC type T
Pulse Channels			
	1	wind speed	Met One Model 014A
Excitation Channels			
	2	wind dir(3.6V)	
	3	Probe temp (4.2V)	

Input Storage locations:
1: panel temp
2: battery voltage
3: Ozone (ppb)
4: TC 1
5: TC 2
6: sol rad 51
7: sol rad 54
8: PRT temp(C)
9: temp holding space
10: RH%
11: wind speed
12: wind dir

Hourly Final Storage Locations:
1: array id
2: year
3: julian day
4: hour,minutes
5: Ozone average
6: TC 1 average
7: TC 2 average
8: SR 51 average
9: SR 54 average
10: probe temp average
11: RH% average
12: ws inst sample
13: wd inst sample
14: battery sample
15: ws average (inst 76)

```
 16:  wind vector mag (inst 76)
 17:  wind vector dir (inst 76)
 18:  wind vector std (inst 76)

 5 min Final Storage Locations
 1:  array id
2:  year
3:  julian day
4:  hour,minute
5:  ozone average
6:  ozone max
7:  ozone min
8:  ozone std dev
9:  ozone 5 min total

*      1        Table 1 Programs
  01: 2         Sec. Execution Interval

01:  P17        Panel Temperature
  01: 1         Loc : (PANEL TEMP)

02:  P1         Volt (SE)
  01: 1         Rep
  02: 15        5000 mV fast Range
  03: 1         IN Chan
  04: 3         Loc : (Ozone ppb)
  05: .001      Mult
  06: 0         Offset

03:  P14        Thermocouple Temp (DIFF)
  01: 2         Reps
  02: 2         15 mV slow Range
  03: 7         IN Chan
  04: 1         Type T (Copper-Constantan)
  05: 1         Ref Temp Loc
  06: 4         Loc : (TC 1&2)
  07: 1         Mult
  08: 0         Offset

04:  P2         Volt (DIFF)
  01: 1         Rep
  02: 2         15 mV slow Range
  03: 5         IN Chan
  04: 6         Loc : (SR 51)
  05: 262.8     Mult
  06: 0         Offset

05:  P2         Volt (DIFF)
  01: 1         Rep
```

```
  02: 2         15 mV slow Range
  03: 6         IN Chan
  04: 7         Loc : (SR 54)
  05: 260.73    Mult
  06: 0         Offset

06:  P1         Volt (SE)
  01: 1         Rep
  02: 5         5000 mV slow Range
  03: 7         IN Chan
  04: 10        Loc : (RH%)
  05: .1        Mult
  06: 0         Offset

07:  P5         AC Half Bridge
  01: 1         Rep
  02: 3         50 mV slow Range
  03: 5         IN Chan
  04: 3         Excite all reps w/EXchan 3
  05: 4000      mV Excitation
  06: 9         Loc : (PROBE TEMP)
  07: 1         Mult
  08: 0         Offset

08:  P59        BR Transform Rf[X/(1-X)]
  01: 1         Rep
  02: 9         Loc : (PROBE TEMP)
  03: 100       Multiplier (Rf)

09:  P16        Temperature RTD
  01: 1         Rep
  02: 9         R/Ro Loc
  03: 8         Loc : (PROBE TEMP C)
  04: 1         Mult
  05: 0         Offset

10:  P3         Pulse
  01: 1         Rep
  02: 1         Pulse Input Chan
  03: 22        Switch Closure; Output Hz.
  04: 11        Loc : (WIND SPEED)
  05: .8        Mult
  06: .447      Offset

11:  P4         Excite,Delay,Volt(SE)
  01: 1         Rep
  02: 5         5000 mV slow Range
  03: 3         IN Chan
  04: 2         Excite all reps w/EXchan 2
```

```
  05: 2        Delay (units .01sec)
  06: 3600     mV Excitation
  07: 12       Loc : (WIND DIR)
  08: .1       Mult
  09: 0        Offset

12:  P10       Battery Voltage
  01: 2        Loc : (BATTERY VOLTAGE)

13:  P92       If time is
  01: 0        minutes into a
  02: 5        minute interval
  03: 10       Set flag 0 (output)

14:  P77       Real Time
  01: 1220     Year,Day,Hour-Minute

15:  P71       Average
  01: 1        Rep
  02: 3        Loc :  (OZONE)

16:  P73       Maximize
  01: 1        Rep
  02: 00       Value only
  03: 3        Loc :(OZONE)

17:  P74       Minimize
  01: 1        Rep
  02: 00       Value only
  03: 3        Loc :(OZONE)

18:  P82       Standard Deviation
  01: 1        Rep
  02: 3        Sample Loc :(OZONE)

19:  P72       Totalize
  01: 1        Rep
  02: 3        Loc :(OZONE)

20:  P96       Serial Output to SM
  01: 30       SM192/716

21:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 10       Set flag 0 (output)

22:  P77       Real Time
  01: 1220     Year,Day,Hour-Minute
```

```
23:  P71        Average
  01: 6        Reps (Ozone,TC1,TC2,SR51,SR54,PROBE TEMP)
  02: 3        Loc

24:  P71        Average
  01: 1        Rep (RH)
  02: 10       Loc

25:  P70        Sample
  01: 2        Reps (WS, WD)
  02: 11       Loc

26:  P70        Sample
  01: 1        Rep (BATTERY)
  02: 2        Loc

27:  P76        Wind Vector
  01: 1        Rep (output: ws avg,wv mag, wv dir, wv std)
  02: 0        Polar Sensor (speed and direc)
  03: 11       Wind Speed/East Loc
  04: 12       Wind Direction/North Loc

28:  P96        Serial Output (send output to SM)
  01: 30       SM192/716

29:  P          End Table 1

*      2        Table 2 Programs
  01: 0        Sec. Execution Interval

01:  P          End Table 2

*      3        Table 3 Subroutines

01:  P          End Table 3

*      4        Mode 4 Output Options
  01: 0        (Tape OFF) (Printer OFF)
  02: 0        Printer 300 Baud


*      A        Mode 10 Memory Allocation
  01: 28       Input Locations
  02: 64       Intermediate Locations

*      C        Mode 12 Security (OSX-0)
  01: 00       Security Option
  02: 0000     Security Code
```

Input Location Assignments (with comments):

Key: T=Table Number
E=Entry Number
L=Location Number

T:	E:	L:		
1:	1:	1:	Loc :	(PANEL TEMP)
1:	12:	2:	Loc :	(BATTERY VOLTAGE)
1:	2:	3:	Loc :	(Ozone ppb)
1:	3:	4:	Loc :	(TC 1&2)
1:	4:	6:	Loc :	(SR 51)
1:	5:	7:	Loc :	(SR 54)
1:	9:	8:	Loc :	(PROBE TEMP C)
1:	7:	9:	Loc :	(PROBE TEMP)
1:	8:	9:	Loc :	(PROBE TEMP)
1:	6:	10:	Loc :	(RH%)
1:	10:	11:	Loc :	(WIND SPEED)
1:	11:	12:	Loc :	(WIND DIR)

Appendix B Calculation of Instruction 2 Multiplier for LI190SB Quantum Sensor

Example:
LI-COR Calibration Constant is 6.35. Each sensor will have a factory documented Calibration Constant.

To convert calibration from microamps to milivolts, multiply the calibration by .604: 6.35 X .604 = 3.8354

To calculate the multiplier for flux density in micromole $s^{-1}m^{-2}$
1000/3.8354 = 260.73

Enter 260.73 as the multiplier in Instruction 2 that applies to this sensor.

Appendix C   Program Loading Notes

Data will be dumping to the SM on the hour - DON'T make any changes then. Key in * 5 A to see the current time.

Do not leave the power switch ON for extended periods of time when the external battery is connected. The 21X will attempt to recharge it's internal alkaline D cell which may explode.

Leave the 21X in either:
* 6 A view Input Storage Locations (A to move forward, B backward)
* 5 A view time
* 7 A view Final Storage Locations

To change the storage module unplug the cable from the "old" and plug in the "new".

To change the external gel cell battery:
Turn power switch ON
Replace the battery
Turn power switch OFF.

To set time and date:
Key in * 5 A
Key in (year) 1992 A
Key in (Julian day) 181 A   [see blue prompt sheet]
Key in (hour minutes) 0907 A   [24 hour clock format]

To load TOWER2 stored as program 1 in the storage module:
Key in the following sequence   * D 71 A 21 A
...E99 means program was not found, try sequence again

To load TOWER3 stored as program 2 in the storage module:
Key in the following sequence   * D 71 A 22 A

After loading a program check Input Storage with * 6 A to make sure the right program loaded and data is being logged.

Figure 4.1.1. Campbell 21X Front Panel Wiring Diagram for 1992.

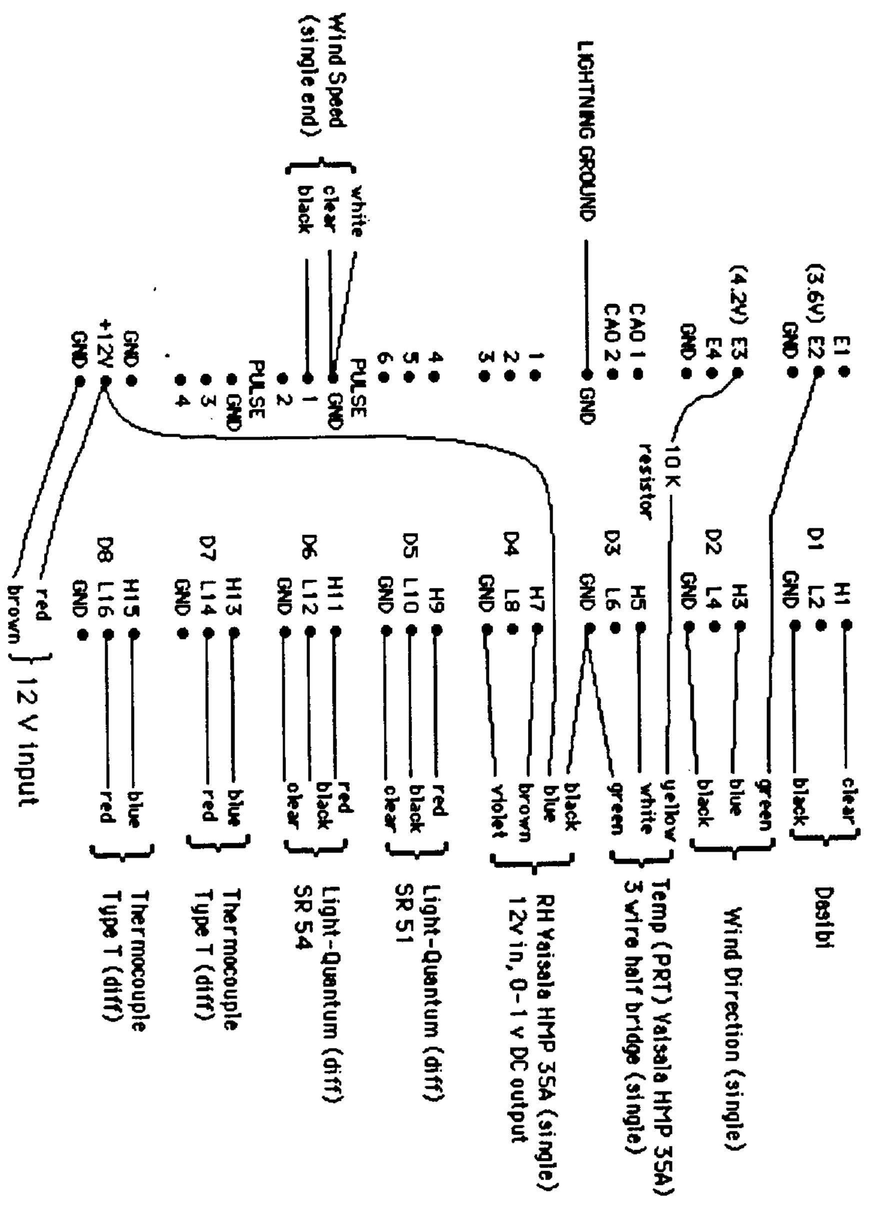
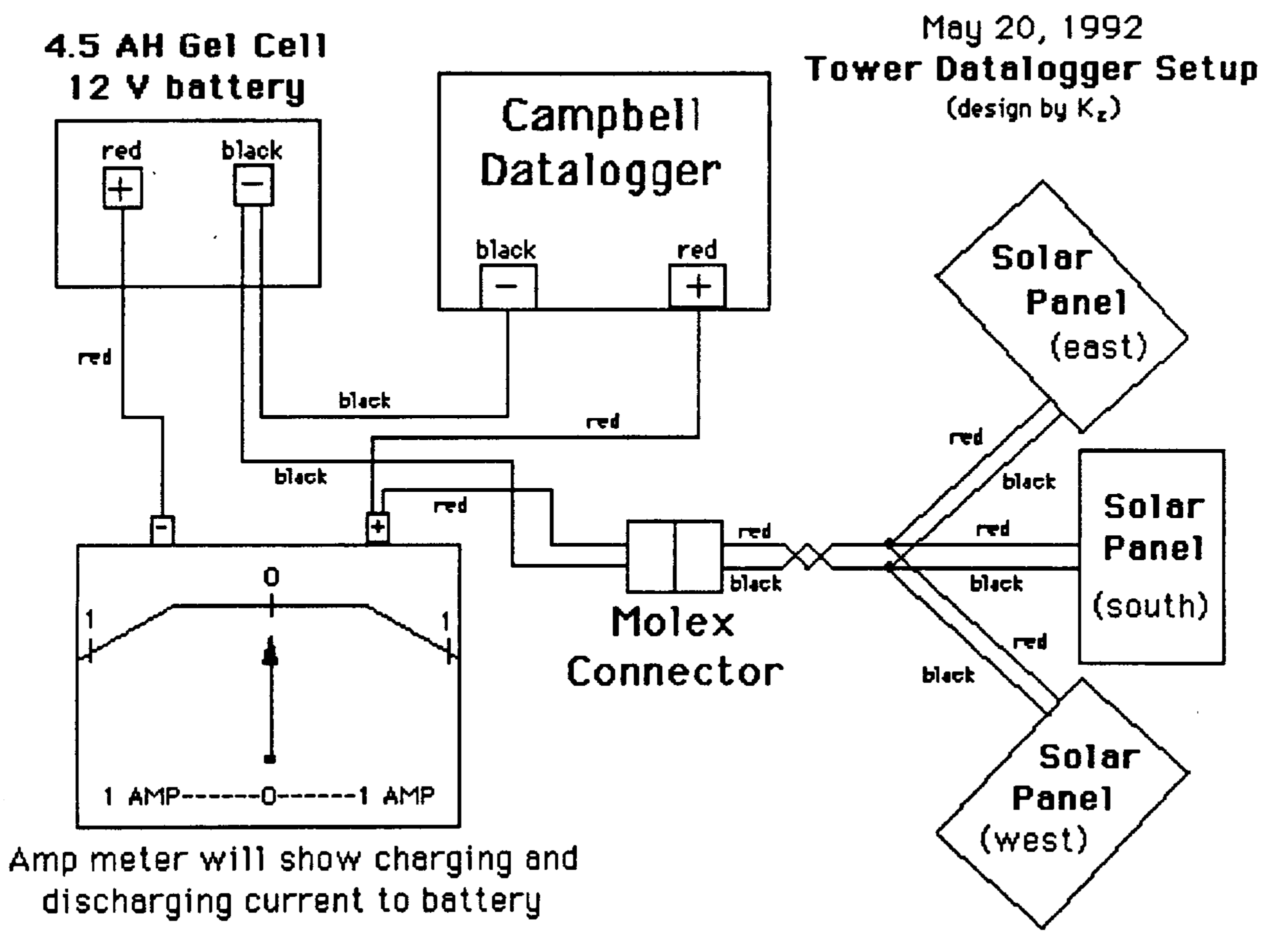


Figure 4.1.2. Tower Datalogger Configuration.



1.0 **General Discussion**

This document provides a description of the instruments and datalogging equipment installed at the top of the 94 ft. scaffold tower at plot 2 of the Barton Flats ARB plots to collect meteorological and ozone data. Meteorological observations are logged from the sensors every 2 seconds and output as hourly averages by a Campbell 21X datalogger to a Campbell SM192 storage module. Ozone data is logged every 5 seconds and output as 5 minute averages for later processing to hourly averages. One of the 2 storage modules is always connected to the Campbell. They are swapped every week and one is brought back to the Lab for downloading. Met data is collected continuously from May to mid-November. Ozone data was collected from mid July to mid September.

1.2 **Measurement Principle**

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

1.4 **Ranges and Typical Values**

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

1.8 **Related Procedures**

Standard Operating Procedures:

- RFL 01 Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1992
- RFL 03 Retrieval and Processing of Scaffold Meteorological and Ozone Data
- RFL 04 Above and Below Canopy Ozone Data Acquisition
- RFL 05 Solar Trailer Operation/Ozone Data Acquisition
- DRI 01 Operation and Maintenance of Meteorological Instruments

2.0 **Apparatus and Instrumentation**

1. Metone 024A Wind Direction Sensor
2. Vaisala HMP 35A Relative Humidity Sensor
3. Licor Quantum Sensors, 2
4. CSI 207 Relative Humidity Sensor
5. Metone 014A Wind Speed Sensors, 2
6. Dasibi Model 1008
7. Solar Trailer
8. Campbell Scientific 21X Datalogger
9. 21X Datalogger Enclosure box
10. Technacell 12 Volt, 4.5 AH Battery (Model 1245)
11. Wooden Box 19x13x11 inch, open top
12. Campbell SM192 Storage Modules, 2
13. Campbell SM532 Peripheral Interface
14. Campbell PC208 Datalogger Support Software
15. IBM Compatible Computer with serial and Parallel port(s), at least 640K memory, 5.25 floppy drive, MS-DOS 3.1 or higher.
16. Printer (attached to the PC)

17. Solarex 440 Solar Energizer
18. Amp Meter

3.0 Calibration Standards

Refer to Standard Operating Procedure DRI 01: Operation and Maintenance of Meteorological Instruments

4.0 Procedures

4.1 Start-up

4.1.1 Instrumentation of the Campbell 21X

The 21X should be fastened into a CSI Enclosure box. Wire the sensors into the Campbell 21X terminals as shown in figure 4.1.1. With a piece of tape label the wind speed sensor that is attached to pulse channel 1 as "top" and the sensor at pulse channel 2 as "foot". Label the quantum sensor attached to differential channel 5 as "full sun" and the quantum sensor attached to chanel 6 as "shade". The Dasibi lead should be connected to the correct 21X terminals but not to the Dasibi. The sensor leads should feed through the opening in the enclosure box.

Read the manual sections for PC208 software, the SM532 peripheral interface, and the SM192 storage module before installing the software and using the storage modules. Install the PC208 Datalogger support software on the PC. Connect the SM532 Peripheral interface to the PC. Using the software SMCOM establish communication with the storage module. At the main menu containing the options for collecting and storage of data and datalogger programs, choose T -- Terminal emulator. For the next section refer to the section covering SM telecommunications commands in the storage module manual. Use command A to check the status of the storage module. Use the E command to do a noload test of the storage module battery. Replace the battery if a 0 is returned. Use the 100E command to do a loaded test of the battery. Replace the battery if a 0 is returned. Check all storage modules that will be used. Finally reset the storage modules using the 1248K command. This will erase all data in the module, reset the pointers, test ram memory, and set the memory switch to "ring memory." Now the storage modules are ready for use.

4.1.2 Programming of Campbell 21X

Use the datalogger support software program, EDLOG, to enter the program INTEN93. Complete listing of the program is in appendix A. INTEN93 collects hourly meteorological readings and 5 minute ozone readings. It will be necessary to make the following changes to the program. The multiplier in instructions 4 and 5 will need to be replaced with one calculated from the calibration constant that was supplied with the Quantum sensors used. Instruction 4 handles the sensor connected at D5, instruction 5 handles the sensor at D6. See appendix B for an example of the calculation. Also, in instruction 13, the correct multiplier to produce output as ppb from the Dasibi should be entered.

Connect the SM532 Peripheral interface to the PC and a storage module. Use the datalogger support software program SMCOM to load the program INTEN93 to all of the storage modules.

The sensors (except the Dasibi) should be connected before loading the program to the 21X. For now the Campbell 21X will be running off it's internal alkaline batteries but an external 12v gel cell will be added later. Turn on the 21X. Connect one of the storage modules to the 21X and load INTEN93 following the directions in appendix C. Connect the positive lead from the external gel cell battery to the +12V terminal and the negative to ground and switch the 21X off. Never leave the power switch on when an external battery is connected. After the program is loaded and the external battery connected, key in * 6 A to check if data is being logged from all the sensors into Input Storage Locations. Use * 5 A to input the correct date and time. After the hour has passed check Final Storage using * 7 A. If everything is working the 21X is ready to be moved to the tower.

4.1.3 Installation of Sensors

Carefully pack the sensors and 21X in a box and transport to tower. Hoist the box to the top of the tower in the cargo net. Unpack and install sensors on the tower. Attach the CSI 207 to the foot of the tower about 10-15 feet off the ground. Attach the wind speed sensor marked "foot" to the base of the tower and place the quantum sensor labeled "shade" in a continously shaded area at the base of a tree. Drop the Dasibi lead for connection to Ozone monitor. The remaining sensors are to be attached to the top of the tower where they are clear of branches and do not interfere with each other. Install the solar panels and connect to the 21X as in figure 4.1.2. Don't forget to turn the power switch back on before the external battery is disconnected for the solar panel installation. Turn the power switch back off after the external battery is reconnected. Place the 21X (in its enclosure box) on a platform. Place the wooden box over the 21X and tie a rope around the box and the platform to keep the 21X from sliding off. Keep a small notebook in the 21X enclosure to note maintenance visits and storage module exchanges. Also keep a copy of appendix C, figure 4.1.1, figure 4.1.2, and the blue 21X Prompt Sheet near the 21X.

4.2 **Routine Operation**

4.2.1 Data

Whenever visiting the tower a check of the datalogger should be made and condition noted in the notebook. Every week the storage module should be exchanged and brought back for a data dump.

4.3 **Shut down**

At the end of the season, disconnect the storage module. Disconnect the solar panels at the molex connector. Turn the 21X switch ON and disconnect the 21X positive and negative leads from the gel cell and amp meter. Turn the 21X switch off. Pack the 21X and sensors in a box and lower in the cargo net.

5.0 **Quantification**

6.0 **Quality Control**

7.0 **References**

Campbell 21X Operator's Manual, Revision 4/89-1.

Appendix A

Program: Campbell 21X Datalogger program for
Intensive Study at
Barton Flats 100 ft Tower.
S.Schilling, 7/12/93

Flag Usage: none

Input Channel Usage:

	channel	variable	sensor
Single ended			
	1	Temp(C)	CSI 207
	2	RH(%)	CSI 207
	3	Wind dir	MetOne 024A
	5	Temp(C)	Vaisala HMP 35A
	7	RH(%)	Vaisala HMP 35A
	13	Ozone	Dasibi
Differential			
	5	solar rad	Licor Quantum 51
	6	solar rad	Licor Quantum 54
Pulse Channels			
	1	ws (top)	MetOne 014A
	2	ws (foot)	MetOne 014A
Excitation Channels			
	1	RH	CSI 207
	2	3.6V WD	MetOne 024A
	3	4.2V RH	HMP35A

Input Storage locations:
1: panel temp
2: battery voltage
3: wind direction
4: CSI 207 temperature (C)
5: CSI 207 RH (%)
6: sol rad 51
7: sol rad 54
8: HMP 35A temp(C)
9: temp holding space
10: HMP 35A RH%
11: wind speed (top)
12: wind speed (foot)
13: ozone

Final Storage Locations Hourly Data:
1: array id
2: year

```
 3:  julian day
 4:  hour,minutes
 5:  CSI 207 Temp average
 6:  CSI 207 RH average
 7:  SR 51 average
 8:  SR 54 average
 9:  HMP 35A temp average
10:  HMP 35A RH average
11:  Max wind speed @ top
12:  Max wind speed @ foot
13:  Min wind speed @ top
14:  Min wind speed @ foot

Page 2   Table 1

15:  WS average (inst 76)@ top
16:  Wind vector mag (inst 76) @ top
17:  Wind vector dir (inst 76) @ top
18:  Wind vector std (inst 76) @ top
19:  WS average (inst 76) @ foot
20:  Wind vec mag (inst 76) @ foot (uses @top WD)
21:  Wind vec dir (inst 76) @ foot     "
22:  Wind vec std (inst 76) @ foot     "
23:  Battery (inst)
24:  Max panel temp
25:  Ozone average

Final Storage Locations 5 min avg.:
   1: array id
   2: year
   3: julian day
   4: hour, min
   5: ozone 5 min average
   6: 5 min max
   7: 5 min min
   8: 5 min standard deviation


*      1        Table 1 Programs
  01: 2         Sec. Execution Interval

01:  P17        Panel Temperature
  01: 1         Loc : (PANEL TEMP)

02:  P11        Temp 107 Probe
  01: 1         Rep
  02: 1         IN Chan
```

```
  03: 1        Excite all reps w/EXchan 1
  04: 4        Loc : (CSI207 TEMP)
  05: 1        Mult
  06: 0        Offset

03:  P12       RH 207 Probe
  01: 1        Rep
  02: 2        IN Chan
  03: 1        Excite all reps w/EXchan 1
  04: 4        Temperature Loc
  05: 5        Loc : (CSI207 RH)
  06: 1        Mult
  07: 0        Offset

04:  P2        Volt (DIFF)
  01: 1        Rep
  02: 2        15 mV slow Range
  03: 5        IN Chan
  04: 6        Loc : (SR 51)
  05: 262.8    Mult
  06: 0        Offset

Page 3   Table 1


05:  P2        Volt (DIFF)
  01: 1        Rep
  02: 2        15 mV slow Range
  03: 6        IN Chan
  04: 7        Loc : (SR 54)
  05: 280.14   Mult
  06: 0        Offset

06:  P1        Volt (SE)
  01: 1        Rep
  02: 5        5000 mV slow Range
  03: 7        IN Chan
  04: 10       Loc : (HMP35A RH%)
  05: .1       Mult
  06: 0        Offset

07:  P5        AC Half Bridge
  01: 1        Rep
  02: 3        50 mV slow Range
  03: 5        IN Chan
  04: 3        Excite all reps w/EXchan 3
  05: 4000     mV Excitation
  06: 9        Loc : (HMP35A TEMP)
  07: 1        Mult
```

```
 08: 0         Offset

08:  P59       BR Transform Rf[X/(1-X)]
 01: 1         Rep
 02: 9         Loc : (HMP35A TEMP)
 03: 100       Multiplier (Rf)

09:  P16       Temperature RTD
 01: 1         Rep
 02: 9         R/Ro Loc
 03: 8         Loc : (HMP35A TEMP C)
 04: 1         Mult
 05: 0         Offset

10:  P3        Pulse
 01: 2         Reps
 02: 1         Pulse Input Chan
 03: 22        Switch Closure; Output Hz.
 04: 11        Loc : (WS TOP, FOOT)
 05: .8        Mult
 06: .447      Offset

11:  P4        Excite,Delay,Volt(SE)
 01: 1         Rep
 02: 14        500 mV fast Range
 03: 3         IN Chan
 04: 2         Excite all reps w/EXchan 2
 05: 2         Delay (units .01sec)
 06: 988       mV Excitation
 07: 3         Loc : (WIND DIR)
 08: .7211     Mult
 09: 0         Offset

Page 4   Table 1


12:  P10       Battery Voltage
 01: 2         Loc : (BATTERY VOLTAGE)

13:  P1        Volt (SE)
 01: 1         Rep
 02: 15        5000 mV fast Range
 03: 13        IN Chan
 04: 13        Loc : (OZONE)
 05: 1         Mult
 06: 0.0000    Offset

14:  P92       If time is
 01: 0         minutes into a
```

```
  02: 5         minute interval
  03: 10        Set flag 0 (output)

15:  P77        Real Time
  01: 1220      Year,Day,Hour-Minute

16:  P71        Average
  01: 1         Rep
  02: 13        Loc

17:  P73        Maximize
  01: 1         Rep
  02: 0         Value only
  03: 13        Loc

18:  P74        Minimize
  01: 1         Rep
  02: 00        Value only
  03: 13        Loc

19:  P82        Standard Deviation
  01: 1         Rep
  02: 13        Sample Loc

20:  P96        Serial Output
  01: 30        SM192/716

21:  P92        If time is
  01: 0         minutes into a
  02: 60        minute interval
  03: 10        Set flag 0 (output)

22:  P77        Real Time
  01: 1220      Year,Day,Hour-Minute

23:  P71        Average
  01: 5         Reps (207 TEMP,RH,SR51,SR54,HMP TEMP)
  02: 4         Loc

24:  P71        Average
  01: 1         Rep (HMP RH)
  02: 10        Loc

Page 5   Table 1

25:  P73        Maximize
  01: 2         Reps (TOP, FOOT)
  02: 00        Value only
```

```
  03: 11        Loc

26:  P74        Minimize
  01: 2         Reps (TOP, FOOT)
  02: 00        Value only
  03: 11        Loc

27:  P76        Wind Vector
  01: 1         Rep (TOP: ws avg,wv mag, wv dir, wv std)
  02: 0         Polar Sensor (speed and direc)
  03: 11        Wind Speed/East Loc (TOP)
  04: 3         Wind Direction/North Loc (TOP)

28:  P76        Wind Vector
  01: 1         Rep (FOOT: ws avg,wv mag,wv dir, wv std)
  02: 0         Polar Sensor (speed and direc)
  03: 12        Wind Speed/East Loc (FOOT)
  04: 3         Wind Direction/North Loc (TOP)

29:  P70        Sample
  01: 1         Rep (BATTERY)
  02: 2         Loc

30:  P73        Maximize
  01: 1         Rep (panel temp)
  02: 00        Value only
  03: 1         Loc

31:  P71        Average
  01: 1         Rep
  02: 13        Loc

32:  P96        Serial Output (send output to SM)
  01: 30        SM192/716

33:  P          End Table 1
```

Appendix B Calculation of Instruction 2 multiplier for LI190SB Quantum Sensor

Example:
LI-COR Calibration Constant is 6.35. Each sensor will have a factory documented Calibration Constant.

To convert calibration from microamps to milivolts, multiply the calibration by .604: 6.35 X .604 = 3.8354

To calculate the multiplier for flux density in micromole $s^{-1}m^{-2}$
1000/3.8354 = 260.73

Enter 260.73 as the multiplier in Instruction 2 that applies to this sensor.

Appendix C   Program loading notes

Do not leave the power switch ON for extended periods of time when the external battery is connected. The 21X will attempt to recharge the internal alkaline D cell which may explode.

Leave the 21X in either:
* 6 A view Input Storage Locations (A to move forward, B backward)
* 5 A view time
* 7 A view Final Storage Locations

To change the storage module unplug the cable from the "old" and plug in the "new".

To change the external gel cell battery:
Turn power switch ON
Replace the battery
Turn power switch OFF.

To set time and date:
Key in * 5 A
Key in (year) 1992 A
Key in (Julian day) 181 A   [see blue prompt sheet]
Key in (hour minutes) 0907 A   [24 hour clock format]

To load program(ie INTEN93) stored as program 1 in the storage module:
Key in the following sequence   * D 71 A 21 A
...E99 means program was not found, try sequence again

To load program stored as program 2 in the storage module:
Key in the following sequence   * D 71 A 22 A

After loading a program check Input Storage with * 6 A to make sure the right program loaded and data is being logged.

Figure 4.1.1. Campbell 21X Front Panel Wiring Diagram for 1993.

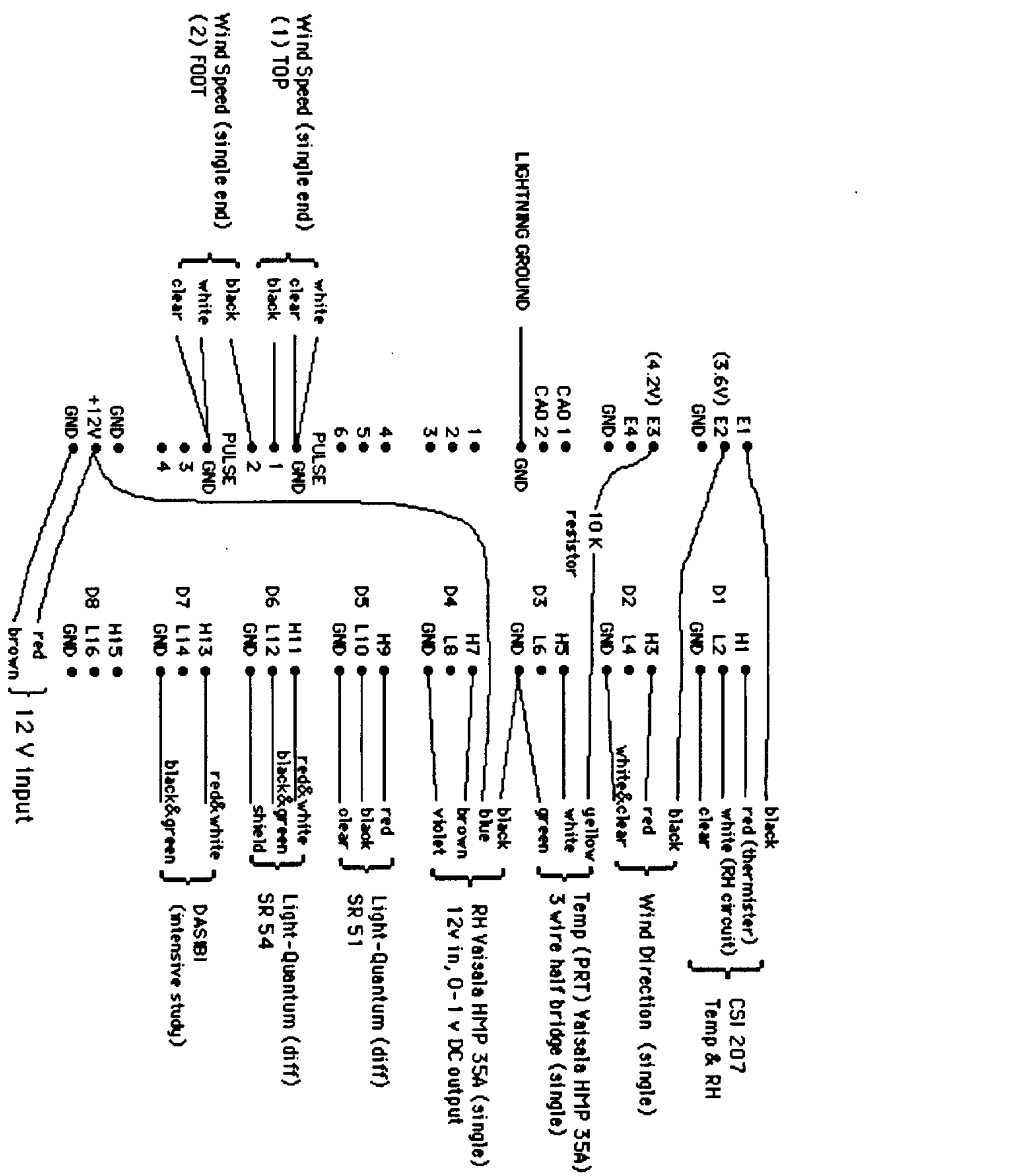
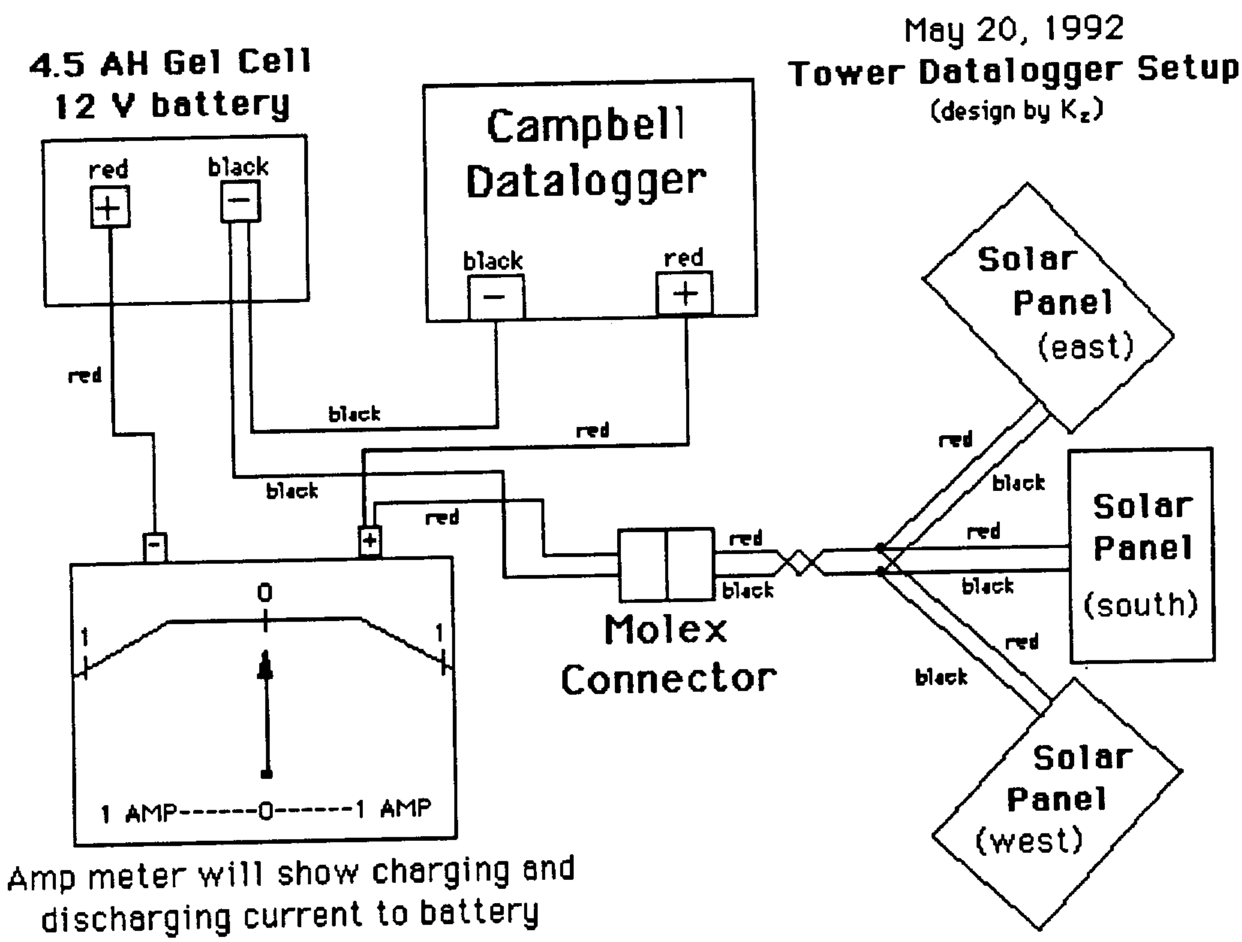


Figure 4.1.2. Tower Datalogger Configuration.



1.0 **General Discussion**

This document provides procedures for retrieval from the storage module, processing and validation of meteorological and ozone data collected at 94 ft. scaffold located in plot 2 of the Barton Flats plots. Each line of met. data saved to the storage module contains the eighteen values listed in figure 1.0.

1.8 **Related Procedures**

Standard Operating Procedures:

- RFL 01 Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1992
- RFL 02 Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1993
- RFL 04 Above and Below Canopy Ozone Data Acquisition
- RFL 05 Solar Trailer Operation/Ozone Data Acquisition

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

1. IBM compatible computer with serial and parallel port(s), minimum of 640 K memory, 5.25 floppy drive, MS-DOS 3.1 or higher.
2. Campbell SM192 storage module
3. Campbell SC532 peripheral interface
4. Campbell PC208 datalogger support software
5. Lotus 123R3
6. dBase III+ (or later)

3.0 **Calibration Standards**

4.0 **Procedures**

4.2 **Start-up**

The computer must be configured to run Lotus 123 and Campbell Datalogger support software. Lotus 123 and dBase should be installed in subdirectories that are included in the PATH statement in the autoexec.bat file. The Campbell software should be installed in a subdirectory named PC208. Consult the manuals for these programs for installation instructions. The SM532 Peripheral Interface should be connected to the computer at serial ports Com1 or Com2 and power as the manual instructs. In the PC208 subdirectory create a Lotus 123 file with the columns named as in figure 4.2, name the file BFTOWER.WK3.

4.3 **Routine Operation**

4.3.1 Data Download

Plug the 9 pin cable of the SC532 interface into the SM192 storage module. See Campbell Scientific Inc. 21X Operators Manual for details of installation. From the subdirectory PC208 enter the command SMCOM. SMCOM will respond asking for what serial port the SM532 is connected to. Enter the com1 or com2. Next SMCOM will ask if the SM232 or SM232A is being used, answer N. SMCOM will try to establish a connection to the storage module. If it fails to find the storage module an error message will appear and SMCOM will terminate. If this happens check all the connections and check which Com port you are using. When a connection is made a banner will appear on the top of the screen with information about the status of the storage module. SMCOM will prompt you for the "Root collection filename (6 characters max):". The filename should be composed of a code for the site and the date the file was collected from the storage module, ie. BF0629 for data recorded at Barton Flats and collected from the storage module on June 29. Any data file(s) you collect from the storage module during this session will be saved in file(s) with this name plus a suffix number and an extension of .DAT. The first file collected is given the suffix one, the second is two, and so on. Next SMCOM will display several options for collecting data files. Choose the option "U -- Collect uncollected data files." This will collect all files stored to the storage module since the last collection. Finally SMCOM will ask for a data format for the collected data. Choose "C -- Comma delineated ASCII arrays". Each element of data on a line is separated by a comma and each line is ended with a CR and LF. Files in this format can be imported into Lotus123. SMCOM will list the files as they are transferred and saved. When the Options screen returns choose "Q -- Quit". There will be a set of one or more files in the PC208 subdirectory with the name you specified as the root collection file name. Make a back-up copy of the files on a floppy. Disconnect the storage module from the SM532 and note on the log sheet taped to the storage module the date the file was collected.

4.3.2 Retrieve the Spreadsheet
Type the command to start Lotus 123. Press the slash key (/) to bring up the menu. Press the F, R keys. Use arrow keys to highlight the file named BFTOWER.WK3, press ENTER.

4.3.3 Import the New Met. Data
Use the down arrow and page down keys until your current position is the top left empty cell under the existing data. Press the slash key (/). Press F,I,N. Use arrow keys to highlight the data file to be imported into the spreadsheet. Press ENTER. Check for gaps in the hour column (4). If necessary fill in missing hours using Insert Row and entering the Julian date and hour of the missing hours. Leave all the other columns blank. If ozone data was being collected, it will be necessary to delete the rows containing the 5 minute averages.

4.3.4 Importing the Ozone Data
To import the ozone data, start in an empty worksheet. Import the data file that contains the ozone data. Delete all the rows that contain hourly averages, keeping only the 5 minute ozone averages. Label the 8 columns as in figure 4.2.2. Insert a blank row after the 5 minute average on the hour (ie between 1300 and 1305). Look at the average, max, min, and std for each 5 min. observation and decide if the data is valid. Especially check the first few readings and when the batteries were being changed. A few averages will have to be deleted, use Range-Erase. As a final check graph the 5 min averages, max, and min. Average the valid 5

minute averages into hourly averages by entering a formula (@avg(E3..E14)) in the blank rows of the AVG column. Get the max and min for the hour. Print the worksheet. Save the worksheet with a name such as TOWEROZ1.WK3. Retrieve the met data worksheet, BFTOWER.WK3. Using the printout, correct the hourly ozone averages. Save BFTOWER.WK3 and exit Lotus123.

4.3.5 Graphing and Validating Met Data
Use RANGE-ERASE to erase the data just imported in column 1. Enter the date as Month Day (June 28) at 2 week intervals at noon. Use this column as graph labels. Graph the data in columns 6-11, and 14-17, putting 2 weeks of data on each graph. Check the graphs for suspect data and anomalies. Especially check the battery voltage in column 14. Print the graphs and file the hard copies.

4.3.6 Saving and Exiting
Save the changes in BFTOWER.WK3 and quit out of Lotus 123. Make a backup copy of BFTOWER.WK3 on a floppy. Check that back-up copies of all new and changed files have been made. Check that the collection is noted on the storage module log sheet.

4.4 **Shut down**
After the data logger has been shut down for the winter and the last file collected from the storage module and appended to the Lotus spreadsheet, the spreadsheet will be imported to dBase IV for final storage. Start Lotus 123 and Retrieve BFTOWER.WK3. Delete column 1 (LABEL). Every cell of the first row must have something in it, put dummy data that can be deleted later. Save the file with a temporary name. Exit Lotus and start the Lotus utility, Translate, with the command TRANS. The FROM format is Lotus 123r3 and the TO format is dBase III+. Choose the file with the temporary name you just saved as the Source file. Change the Target file name to TMET92.DBF. After a successful translation, quit out of the Translate utility and start dBase. USE the file just created and Browse to check if the translate was OK.

5.0 **Quantification**

6.0 **Quality Control**

7.0 **References**

dBase IV Manual
Campbell Scientific Inc. 21X Operators Manual
Lotus 123R3 Manual

Figure 1.0 Contents of Data Array saved to Storage Module

Array id
Year
Julian day
Hour, minute
Ozone *
Temperature @ 74 ft *
Temperature @ 44 ft *
Solar Rad (full sun) *
Solar Rad (under canopy) *
RH Probe Temperature *
RH % *
Wind Speed Inst.
Wind Direction Inst.
Battery voltage
Wind speed average *
Wind Vector Mag. *
Wind Vector Dir. *
Wind Vector Std. *

* Hourly averages

Figure 4.2.1 Met Data Column Titles for Lotus Spreadsheet

LABEL
YEAR
JDAY
HOUR
OZONE
TC_TOP
TC_MID
SR_FULL
SR_UNDER
TEMP_P
RH_P
WSI
WDI
BAT
SCS
VWS
VWD
SIG60

Figure 4.2.2 Ozone Data Worksheet Column Names

ARRAY ID
YEAR
DAY
HOUR
AVG
MAX
MIN
STD

Figure 4.4 TMET92.DBF Database File Structure

Field	Field Name	Type	Width	Dec	Index
1	YEAR	Numeric	5		N
2	JDAY	Numeric	5		N
3	HOUR	Numeric	5		N
4	OZONE	Numeric	5	2	N
5	TC_TOP	Numeric	5	2	N
6	TC_MID	Numeric	5	2	N
7	SR_FULL	Numeric	7	2	N
8	SR_UNDER	Numeric	7	2	N
9	TEMP_P	Numeric	6	2	N
10	RH_P	Numeric	6	2	N
11	WSI	Numeric	6	3	N
12	WDI	Numeric	6	2	N
13	BAT	Numeric	6	2	N
14	SCS	Numeric	6	2	N
15	VWM	Numeric	6	2	N
16	VWD	Numeric	6	2	N
17	SIG60	Numeric	6	2	N

1.0 **General Discussion**

The HP Above and Below Ozone system is a data acquisition system controlled by a Hewlett-Packard 71B Programmable Computer that alternately samples air from 2 intake lines and outputs an average ozone amount for each line to a printer. The printed data can be typed into a spreadsheet and reformatted into hourly averages.

1.6 **Responsibilities of Personnel**

It is the responsibility of the field technician to make sure that the system is operating properly. If the system is not operating properly the field technician should identify and take the necessary steps to alleviate this problem.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 01 Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1992

RFL 03 Retrieval and Processing of Scaffold Meteorological and Ozone Data

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**

1. Hewlett-Packard 71B
2. Dasibi 1003AH
3. HP Data Acquisition/Control Unit 3421A
4. HP-IL/GPIO Interface 82165A
5. Thermal Printer 82162A
6. Pump/Solenoid/Intake Line assembly

3.0 **Calibration Standards**

See Standard Operating Procedure DRI 03: Operation and Maintenance of the Dasibi 1003 PC Ozone Analyzer

4.0 **Procedures**

4.1 **General Flow Diagram**

The HP 71B functions as the controller in a HP-IL loop consisting of a thermal printer, HP Data Acquisition Unit, and HP-IL/GPIO interface (see Figure 4.1.1). The 71B controls the solenoid switching through the HP-IL/GPIO interface. The data acquisition unit monitors data from the Dasibi and sends it to the controller when requested. When the program is started the solenoids switch intake to side 0. Air is pulled through intake side 0 to the Dasibi for 2 minutes. During the 3rd minute 4 ozone readings (approx. 17 sec. apart) are sent to the 71B to be averaged. At the end of the 3rd minute, the minutes elapsed since start, side #, average of the 4 readings, and number of readings in the average are printed on the printer and the solenoids switch to intake side 1. Air is pumped through side 1 intake line to the Dasibi for 2 minutes. During the 3rd minute four ozone readings are sent to the 71B and averaged. At the end of the 3rd minute the data is printed as before and the solenoids switch back to intake side 0. The program will continue to switch intake lines and print data until the operator interrupts the program by pressing the 71B ON key.

4.2 **Start-up**

Enter the program listed in appendix A into the 71B and save as DASIBI. Keep the instruction sheet in appendix B with the system.

4.3 **Routine Operation**

Turn on everything and enter the following commands:
RESET HPIL
RESTORE IO
EDIT DASIBI
RUN [this is a key]
Enter an identification line up to 80 characters containing the date and start time, eg 5/31/92 10:34
The ID line and column headers will be printed. The screen on the 71B will display program progress messages, elapsed minutes, and ozone readings. Every three minutes a line of data will be printed consisting of: Minutes since start, side (0 or 1), Ozone average(ppb), # readings in average.

A paper roll for the thermal printer is 80 ft. long. The program prints 480 lines per 24 hours. A roll of paper will last for about 12 days. When the end of the roll is near, stop the program by pressing the ON key. Put the new paper in and restart the program as above. Write the date and time OFF on the finished paper roll.

4.4 **Shut down**

Hit the ON key to stop the program. Turn everything off.

5.0 **Data Processing**

Transfer the data from the paper printouts to electronic form. Each line of data on the printout including "minutes since start", side number, and average is typed into a spreadsheet such as EXCEL or LOTUS 123. The hourly averages are then calculated and can be further analyzed or graphed.

The labelled paper tapes are to be stored and back-up copies and printouts of electronic data are to be maintained.

6.0 **Quality Control**

Not Applicable

7.0 **References**

HP-71 Owner's Manual, February 1985
HP-71 Reference Manual, May 1984
HP-IL Interface (HP 82401A) Owner's Manual For the HP-71, January 1985
HP82165A HP-IL/GPIO Interface Owner's Manual, February 1982
3421A Data Acquisition/Control Unit Operating, Programming, and Configuration Manual, March 1984

Appendix A

```
10 ! DASIBI-DATA ACQUIS; SWITCH SIDES EVERY 3 MINUTES
20 ! 8/07/90
30 OPTION BASE 0
40 DIM S(1),I$[200]
50 D=DEVADDR("HP3421A")
110 INPUT "ID:";I$
200 PRINT I$ ! ID
210 PRINT "MIN SIDE OZ(ppb) N"
250 S(0)=0 @ S(1)=0 @ A=0 @ P=0 @ V=0
251 T0=0
252 SETTIME 0
260 'MAIN':
270 T=TIME
280 IF T<T0 THEN DISP "WAITING ";TIME$ @ GOTO 270
290 DISP "READING ";TIME$
300 T1=T-T0 ! ELAPSED SECONDS
310 M=INT(T1/60) ! ELAPSED MINUTES
320 M3=INT(M/3) ! ELAPSED 3MIN INTERVALS
330 IF M#M3*3 OR M=A THEN GOTO "SIDE"
340 IF S(1)=O THEN GOTO "SIDE"
350 S(0)=INT(S(0)/S(1)*1000+.5)
360 ! PRINT
361 PRINT USING "DDDDD,1X,D,1X,4D,AAA,1X,D";M,S0,S(0)," AV",S(1)
400 S(0)=0 @ S(1)=0
410 A=M
420 'SIDE':
430 S0=MOD(M3,2)
440 IF S0#1 THEN V=0 @ GOTO "READING"
450 V=255 ! 8 ONE BITS
460 'READING':
470 OUTPUT :INTRFCE USING "#,K";CHR$(V) ! 0 OR 255
480 ! SUM OVER 3RD MINUTE FOR AVE
490 IF M#M3*3+2 THEN GOTO "MAIN"
500 OUTPUT :D ;"DCV12"
510 ENTER :D ;X
520 X1=INT(X*1000+.5)
525 DISP "SIDE ";S0;X1
530 IF P=M THEN GOTO 570
560 GOTO 590
570 REM
590 P=M
600 S(0)=S(0)+X @ S(1)=S(1)+1
610 WAIT 17
620 GOTO "MAIN"
```

Appendix B

DASIBI INSTRUCTIONS:

Turn everything on and enter the following commands:
RESET HPIL
RESTORE IO
Use these commands anytime the system locks up with a HPIL loop broken error message (hit ON to clear the error message, check all the loop connections and that everything is turned on.)

To run the program:
EDIT DASIBI
RUN
Enter

An identification line up to 80 characters containing the date and start time.

To stop the program:
Hit ON

OTHER USEFUL COMMANDS:

To print a listing of a program
PLIST filename

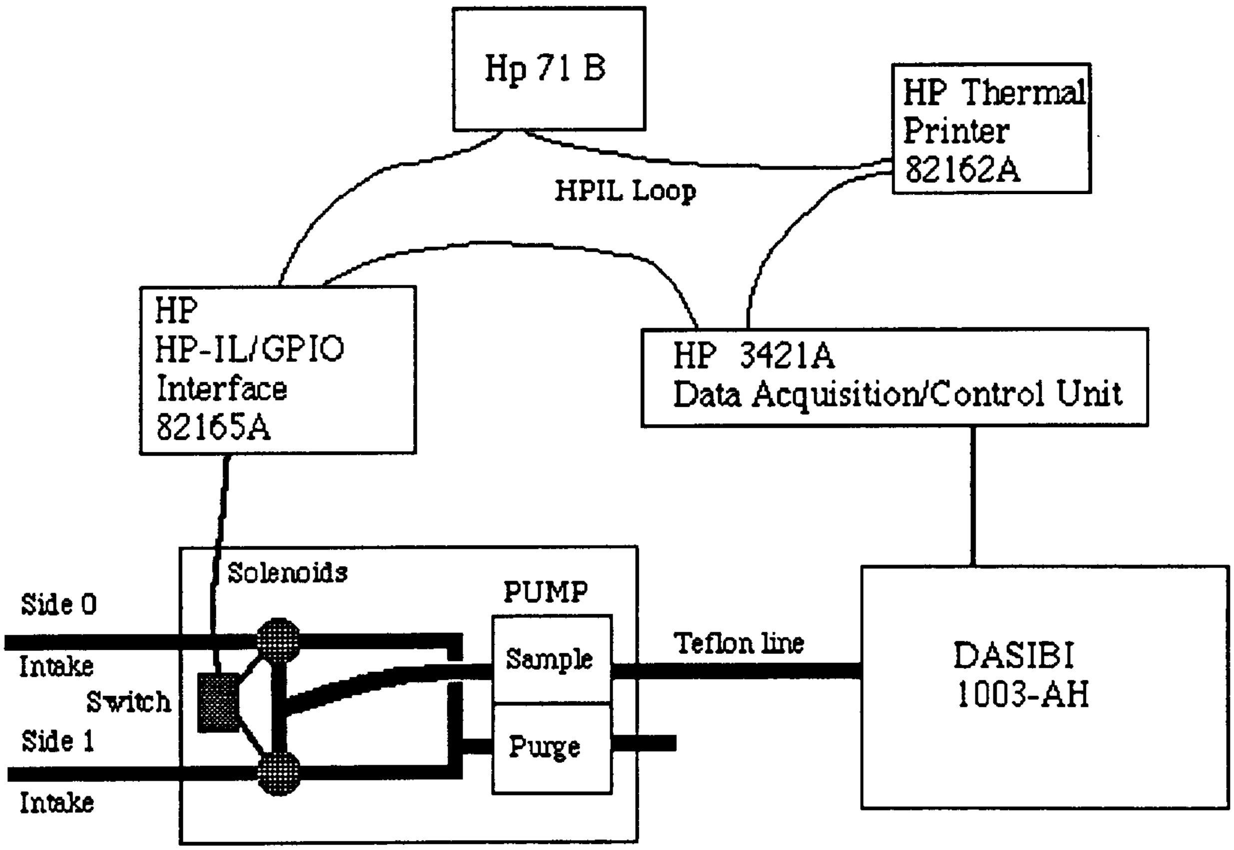
To list files on the HP-71:
CATALL
down-arrow to scroll through names

To delete a file from HP-71:
PURGE filename

To copy a file:
COPY fromfile TO tofile

To edit the file:
EDIT filename
use up and down arrows to scroll through lines
make the changes and press END LINE to save change to line

Figure 4.1.1. Hewlett-Packard Above and Below Canopy Ozone Data Acquisition System.



1.0 General Discussion

1.1 Purpose of Procedure

The purpose of this standard operating procedure is to describe the methods employed to measure ozone levels at a remote field site where no power is available to operate the ozone monitoring device.

1.2 Measurement Principle

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

1.3 Measurement Interferences and their Minimization

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

1.4 Ranges and Typical Values of Measurement Obtained by this Procedure

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

1.5 Typical Lower Quantifiable Limits, Precision, and Accuracy

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

1.6 Responsibilities of Personnel

It is the responsibility of the field technician to check the batteries periodically to make sure that they are sufficiently charged to run the ozone monitor. Similarly, the field technician needs to make sure that the batteries are not being overcharged. If the ozone monitor is using less power than the solar panels are supplying it could lead to overcharging and is then necessary to decrease the number of panels operating in the system. During normal operation overcharging should not be a problem. It is also the responsibility of the field technician to ensure that the distilled water in the battery cells remains full. Low water levels in the batteries can lead to poor energy storage, which limits the length of operation, and if allowed to get too low can become hazardous. Finally, it is necessary for the field technician to perform routine checks and maintenance on the ozone monitor and to keep the solar panels free of dirt and debris to minimize complications and maximize efficient operation.

1.8 Related Procedures

Standard Operating Procedures:

RFL 02	Installation of Meteorological Sensors and Programming of the 21X Datalogger - 1993
RFL 03	Retrieval and Processing of Scaffold Meteorological and Ozone Data
DRI 02	Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

2.0 Apparatus, Instrumentation, Reagents, and Forms

2.1 Apparatus and Instrumentation

The solar powered, ozone sampling system consists of a solar trailer outfitted with eighteen 47 x 14 inch Motorola solar panels (Model no. MSP43A40) on three moveable platforms, or arrays, which can be rotated from a horizontal position up to approximately a 45 degree angle. This increases the ability to catch the sunlight thereby maximizing the amount of energy captured. An additional three solar panels were attached to hang vertically from the original eighteen panels to further increase the amount of energy captured. These solar panels use the solar rays to recharge eight 24 volt deep charge batteries. These eight batteries are the power source for the Dasibi ozone analyzer which measures ozone in the 0 to 1.0 ppm range. A Topaz static inverter is used to convert the DC voltage from the batteries into AC voltage to run the ozone analyzer.

Due to the degradation of batteries from lead sulfate build-up during normal use the solar trailer batteries were each equipped with a Solargizer. These Solargizers are produced by Motor Products and are designed to store current from a small solar panel in an electronic circuit which then emits this energy at a high frequency into the battery. This knocks the lead sulfate off of the plates which increases the life of the battery. The Solargizers also provide a minimal amount of recharging capability.

2.2 **Supplies**

1. distilled water. Used to periodically refill the battery cells.
2. hydrometer. Used to check the charge condition of the batteries. The field technician may charge the batteries if the battery voltages are too low or may shut some of the solar panels off if the batteries appear to be overcharging.
3. battery filling bottle. This bottle can be purchased at a local automotive parts store. It has a spout designed to fill the battery cells to the precise level and prevents spillage.
4. car duster. Used to remove dirt and debris from the surface of the solar panels. This duster can be purchased at a local automotive parts store.
5. replacement inlet filters. Used to prevent large particulates from entering the ozone monitor through the air intake line. This filter should be replaced at least every month (preferably sooner during high pollution periods).
6. Dasibi replacement parts. It is necessary to have certain replacement parts on hand due to malfunctions during normal ozone sampling. It is the operator's decision as to which replacement parts he will keep on hand, however, speedy repairs prohibit data loss.
7. vinyl jacketed, shielded cable. Used to connect the Dasibi data output terminals to the Campbell 21X Datalogger.
8. Campbell 21X Datalogger

3.0 Calibration Standards

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

4.0 Procedures

4.2 Start-up

4.2.1 Solar Trailer

Before ozone monitoring could begin it was necessary to tow the solar trailer to the desired sampling site. Once there the trailer was levelled to prevent the batteries from leaking. A chain link fence was erected around the trailer to prevent people and animals from tampering with the equipment. The solar panels were then rotated up into the position to most effectively capture solar rays.

To gather data being generated by the Dasibi it was necessary to run the shielded cable from the data output terminals to the Campbell 21X datalogger located at the top of the tower. This allowed ozone data to be collected in the same datalogger as the rest of the meteorological variables and made it possible to collect the ozone data, along with the other data, every two weeks by switching the storage module (refer to RFL 01 and RFL 02). Finally, an air intake line was attached to the intake port of the ozone analyzer. The other end was attached to a vertical rod at a point approximately twelve feet off of the ground. This was to keep anything from upsetting the intake line as well as to prevent any vehicles arriving at the site from emitting exhaust directly into the line and affecting the ozone readings. Once this was done the power to the solar trailer, the static inverter and the ozone analyzer were turned on.

4.2.2 Dasibi Ozone Analyzer

For further start-up details refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer.

4.3 Routine Operation and Maintenance

4.3.1 Solar Trailer

The field technician needs to closely monitor the condition of the batteries and take any steps necessary to alleviate problems. During long periods of cloudiness it may be necessary to shut the ozone analyzer off because not enough solar energy is being delivered to the batteries. Once an ample charge has been regained the ozone analyzer should be turned back on. Water levels in the batteries should also be maintained by the field technician using the distilled water provided.

4.3.2 Dasibi Ozone Analyzer

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

4.4 Shut down

4.4.1 Dasibi Ozone Analyzer

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer

4.4.2 Solar Trailer

Once the ozone analyzer has been shut down it is necessary to shut off the power to the rest of the solar trailer. After this has been done remove the air intake line from the vertical rod and unhook it from the air intake port on the back of the analyzer. Remove the three additional solar panels and the Solargizers from the solar panel arrays and rotate the arrays back down to a flat, horizontal position. Disassemble the chain link fence and transport the solar trailer back to the laboratory.

5.0 Quantification

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer (where applicable)

6.0 Quality Control

Refer to Standard Operating Procedure DRI 02: Operation and Maintenance of the Dasibi 1008 AH Ozone Analyzer (where applicable)

7.0 References

1.0 **General Discussion**

1.1 **Purpose of Procedure**

The purpose of this standard operating procedure is to describe the materials needed and methods to employ to create an inexpensive, easily constructed rain and throughfall collector which will allow wet deposition collections to be made without previously exposing the sample container to contaminants.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 07 Placement of Rain and Throughfall Collectors
RFL 08 Rain and Throughfall Collection Method
RFL 09 Chemical Processing of Rain and Throughfall Samples

2.0 **Apparatus, Instrumentation, Supplies, and Forms**

2.1 **Apparatus and Instrumentation**

2.1.1 Description

The rain and throughfall collector is designed to open only at the beginning of a precipitation event by using a counter-weighted cover which is kept in place using a strip of water soluble paper. As the precipitation event begins water is caught in a funnel located above the water soluble paper and is directed downward onto the paper causing it to dissolve. Once the paper dissolves the counterweight, having no further resistance, drops and causes the cover to pivot up and away from the sample container allowing rainfall collection to begin.

The sample container is a commercially available rain gauge unit made of an inert plastic. It consists of a measuring tube, an outer cylinder, a funnel, and a backplate. This unit is housed in a wooden frame constructed of commercially available lumber which is then treated with a commercial water sealant and painted in a camouflage pattern to make it impervious to water and less noticeable to passers-by.

2.1.2 Maintenance

The only maintenance for the rain and throughfall collectors are the occasional repairs required due to inquisitive woodland and urban creatures.

2.2 **Supplies**

Refer to "A Simple, Inexpensive Rain and Canopy Throughfall Collector" - Table 1

4.0 **Procedures**

4.1 **Construction**

Refer to "A Simple, Inexpensive Rain and Canopy Throughfall Collector" - Pages 3-5, Figures 1-3

7.0 **References**

Glaubig, Robert and Anthony Gomez. "A Sirple, Inexpensive Rain and Canopy Throughfall Collector."
Productive Alternatives memo

1.0 **General Discussion**

Rain and throughfall collectors, construction described in RFL 06, were placed in plots 1, 2, 3 and at the meterological station of the Barton Flats study area. The collectors were placed under tree canopies of ponderosa pines, white firs, and black oaks (throughfall collectors) and away from the influence of tree canopies (rain collectors).

1.1 **Purpose of Procedure**

The purpose of the collectors was to compare the nutrient concentrations and volumes inside the canopy with those away from the influence of the canopy. In addition, a comparison was made within and between species, and within and between different years of sample collection.

1.2 **Placement Schedule**

Spring 1992	Plots 2, 3	30 throughfall collectors were placed under ponderosa pines 3 rain collectors were placed
	Plot 1	28 throughfall collectors were placed under ponderosa pines 3 rain collectors were placed
	Met station	1 throughfall collector was placed under a ponderosa pine 1 rain collector was placed
Spring 1993	All plots	3 additional rain collectors were placed
	Plots 1, 2	10 throughfall collectors were placed under black oak canopies 10 throughfall collectors were placed under white fir canopies
Spring 1994	Plots 1, 2	Many throughfall collectors were removed leaving collectors under only 10 trees of each of the three species
	Plot 3	All rain and throughfall collectors were removed

The exact trees used during each year can be found in RFL 08.

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 06 Construction of Rain and Throughfall Collectors
RFL 08 Rain and Throughfall Collection Method

2.0 **Apparatus**

1. Collectors w/legs
2. Rain collection cylinders
3. Tools: Hammer
   String Level
   Socket
   Screw drivers - crosshead and flathead

2.0 **Apparatus** (cont.)

Pliers
Loppers
Meter stick
Compass

4. Tree location list

4.0 **Procedures**

4.3 **Placement Procedure**

Throughfall Collectors:
With only a few exceptions, the collecters were placed with the center of the collection funnel 0.85 to 1.05 meters away from the tree trunk. On one ponderosa pine within each of the three plots, four collectors were placed away from the trunk in the northwest, southwest, northeast, and southeast directions. The collector locations around other trees were chosen to maximize the canopy above it while assuring other species would not interfere with the throughfall; compass direction from the tree was not considered.

Rain Collectors:
The rain collectors were placed in each of the three plots and at the meteorological station. The placement criteria were to have the collector as close as possible to a throughfall collector but clearly out of the influence of any canopy.

Once the location of each collector was chosen, the three legs were installed in the collectors. The collector was rotated so two of the legs were on the down slope. Loppers were used to level the collector by cutting the length of one or more legs; the string level was utilized. Once level, the anchor rebar was pounded into the ground directly below the collector base to assure the collector was steady. The collector was triggered as described in RFL 08.

4.4 **Winterization**

Between each collection season, the collectors were prepared for the winter. At the final collection of each season, the collection cylinders and lids were brought back to the lab for storage. Each collector was covered with a 30 gallon trash sack, and the sack was securely attached around the collector base.

7.0 **References**

1.0 **General Discussion**

1.1 **Purpose of Procedure**

The purpose of this standard operating procedure is to describe the methods employed for the collection of rain and throughfall samples from the ARB Barton Flats field plots.

1.2 **Measurement Principle**

Samples are collected in rain and throughfall collectors designed specifically for this purpose by the USDA Forest Service. These collectors are equipped with covers which are removed by a triggering device only at the beginning of a precipitation event. As the event begins the precipitation is caught in a small funnel located on the cover of the collector. The precipitation is then directed out of the bottom of the funnel and strikes a water soluble paper. The paper dissolves after becoming moist and allows a counterweight to pull the cover off of the collector. This process only takes a few seconds thereby limiting the amount of precipitation which is lost during the uncovering process.

This triggering system limits the amount of contaminants which may be introduced into the collection device before the precipitation event occurs. Contamination is also limited by using plastic to construct any pieces of the collector which may contact the sample. The collection cylinder which holds the sample is capable of holding approximately 11 inches of precipitation and has volume markings every 0.01 inches up to 1.00 inch.

1.3 **Measurement Interferences and their Minimization**

1.3.1 Passive Deposition

Passive deposition occurs when particles are deposited into the rain and throughfall collectors before or after the precipitation event has taken place. Covers have been installed to trigger at the beginning of the precipitation event to limit passive deposition beforehand. Trips are made to gather samples and reset the collectors as soon after the precipitation event as possible to prevent passive deposition into the the samples waiting to be collected.

1.3.2 Evaporation

Exposure of the sample to direct sunlight and low relative humidity after the precipitation event has occurred can result in the loss and concentration of the sample through evaporation. Trips are made to gather samples as soon after the precipitation event as possible to limit evaporation.

1.3.3 Premature Triggering

Contamination of the sample can be caused by a premature triggering of the rainfall collector thereby allowing foreign material to be deposited into the clean cylinder. It is possible for heavy dews or fogs to dissolve the trigger paper causing premature triggering. Trips are made at frequent intervals to assure that the collectors are properly triggered, the triggering paper is in good condition, and to remove any foreign material which may have accumulated in uncovered collectors.

1.3.4 Failed Triggering
Partial or total loss of the sample can occur due to an improper triggering of the rainfall collector. Special care is taken when setting the trigger on the collector to make sure that the trigger counterweight and the trigger line are not caught on any part of the collector and that they are placed properly in the weight tube. These precautions should result in proper triggering and complete sample retrieval.

1.3.5 Interferences
Because of the environment in which this research is taking place it is inevitable that there will be interferences caused by humans and animals. Therefore certain precautions were taken to try to reduce the frequency of these interferences. To reduce the interferences caused by man each collector was painted in a camouflage pattern, using brown and green paint, to cause it to blend in with the natural surroundings. This makes the collector less noticeable and therefore less likely to be tampered with. Furthermore, a sign was placed on each collector asking people not to tamper with it to prevent loss and contamination of the sample. This method, however, relies on the integrity of people so may have little or no effect.

To reduce the impacts caused by animals a short length of rebar was anchored to the base of the collector and then driven into the ground to stabilize the collector. Although this does nothing to deter the truly avid woodland creatures from destroying the collector it does reduce damage done by those which are only mildly curious.

1.4 **Ranges and Typical Values of Measurement Obtained by this Procedure**
Not Applicable

1.5 **Typical Lower Quantifiable Limits, Precision, and Accuracy**
The rain and throughfall collector designed by USDA Forest Service researchers[1] is capable of collecting approximately 11 inches of precipitation. The volume measurement is accurate to ±0.01 inches. If less than 0.01 inches of precipitation is collected the measurement should be recorded as "T" for trace[2]. The delay involved in the triggering of the collector at the beginning of the precipitation event has been shown to have little or no importance in the final volume measurement[1].

1.6 **Responsibilities of Personnel**
Field technicians are responsible for carrying out this standard operating procedure when collecting rain and throughfall samples in the field, completion of the rain and

throughfall collection data forms, and transmitting samples to the laboratory.

The field operations supervisor is responsible for scheduling sample collection dates, preparing supplies needed for sample collection, reviewing data forms, identifying and resolving discrepancies, and receiving samples from the field technicians and transferring them to the laboratory.

1.7 **Definitions**

DDW - distilled, deionized water

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 06 Construction of Rain and Throughfall Collectors
RFL 07 Placement of Rain and Throughfall Collectors
RFL 09 Chemical Processing of Rain and Throughfall Samples

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**

Literature showing the collector and describing instrumentation has been attached to this procedure.

2.2 **Supplies**

1. distilled, deionized water in a wash bottle. Used to clean the outer cylinders and covers of the rain and throughfall collectors.
2. kimwipes. Used to clean and dry the outer cylinders and covers of the rain and throughfall collectors.
3. trigger paper. Water soluble paper which, once a rainfall event begins, dissolves and allows the cover to pivot away from the collector. Used to reset the triggering mechanism once a rainfall event has occurred.
4. replacement measuring tubes. Placed into the collector at the time of retriggering to replace the original measuring tube. This allows measurements, transfer of the sample, and the cleaning of the measuring tube to all take place in the laboratory.
5. labelling tape. Used to mark identification numbers onto the measuring tubes at the time of collection.
6. permanent marker. Used to write identification numbers on the labelling tape which is placed on measuring tubes at the time of collection.
7. parafilm. Used to cover the collected measuring tubes to prevent the loss of sample during transportation.

2.3 **Forms**

Examples of the forms used for recording field data are attached.

3.0 **Calibration Standards**

Not Applicable

4.0 **Procedures**

4.2 **Start-up**

See Standard Operating Procedure RFL 07: Placement of Rain and Throughfall Collectors.

4.3 **Routine Operation**

4.3.1 Collection of Samples

1. Upon arrival at the rain or throughfall collector (see attached data sheets for collector locations) note on the field data sheet whether or not the collector properly triggered.
2. Remove the measuring tube containing the sample from the rain or throughfall collector and indicate the level of volume on the field data sheet. Make sure that the measuring tube is level when this reading is taken. If there was a large precipitation event and the sample has overflowed into the outer cylinder it will be necessary to pour the contents of the measuring tube into the outer cylinder to thoroughly mix the sample. Pour the contents back into the measuring tube in separate increments, noting the volume on each one, until the entire volume has been measured and the measurements combined for a sum total. Keep a representative sample of between 0.50 and 1.00 inch to bring back to the laboratory for analysis. The rest may be disposed of in the field.
3. Cover the measuring tube containing the sample with a piece of parafilm to prevent any loss of sample. Place a small piece of labelling tape on the sample tube and, using the permanent marker, indicate which collector this sample was taken from. Place the measuring tube containing the sample into the box to be transported back to the laboratory.
4. Rinse the outer cylinder and funnel thoroughly using kimwipes and the wash bottle with DDW and place a clean measuring tube into the outer cylinder. Set the funnel back on the outer cylinder making sure that the spout is seated in the measuring tube.
5. Clean the bottom of the cylinder cover using kimwipes and DDW to prevent contaminants from falling into the clean measuring tube.
6. Place the cylinder cover over the rain gauge and, using the trigger paper, retrigger the collector[1].

4.3.2 Measuring Tube Cleaning

1. Remove the identification label from the measuring tube.
2. Partially fill the measuring tube with deionized water and, using an appropriate brush, thoroughly scrub the inside and outside of the measuring tube to dislodge any contaminants.
3. Rinse the measuring tube 3 more times with deionized water and then 3 times with DDW.
4. Shake the excess water from the tube and place it upside down on kimwipes on top of the laboratory bench and allow it

to dry.

5. Once dry, place the measuring tube upside down in a box lined on the bottom with kimwipes so they can be transported to the field and used in the retriggering process of the rain and throughfall collectors.

5.0 **Quantification**

Not Applicable

6.0 **Quality Control**

Not Applicable

7.0 **References**

Glaubig, Robert and Anthony Gomez. "A Simple, Inexpensive Rain and Canopy Throughfall Collector."
Productive Alternatives memo

RAIN COLLECTORS

Collection Date: 1992
Collected By:

PLOT 1

Tree No.	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
2	1 UP 11 R					
7	1 UP 8 L					
15	8 UP 10 R					
16	8 UP 4 R					
18	8 UP 0 R					
22	8 UP 20 R					
30	11 UP 19 L					
47	30 UP 7 R					
67	43 UP 16 R					
72	53 UP 3 L					
73	57 UP 5 L					
76	56 UP 20 L					
77	63 UP 6 L					
98	81 UP 21 L					
169	7 UP 26 R					
173	56 UP 29 R					
177	51 UP 30 L					
178	88 UP 27 L					
92 NW	81 UP 21 L					
92 NE						
92 SW						
92 SE						
69 I	48 UP 16 R					
69 O						
116 I	91 UP 5 L					
116 O						
170 I	29 UP 34 L					
170 O						
Station I						
Station O						

PLOT 2

Tree No.	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
204	4 UP 1 L					
217	8 UP 6 L					
225	9 UP 12 R					
228	8 UP 5 R					
234	12 UP 10 R					
241	16 UP 20 R					
242	16 UP 5 R					
253	12 UP 18 L					
263	16 UP 10 L					
270	19 UP 3 L					
278	21 UP 5 R					
289	36 UP 1 R					
291	25 UP 6 L					
342	47 UP 20 R					
366	68 UP 3 L					
368	69 UP 0 R					
377	83 UP 11 R					
383	84 UP 9 L					
414	115 UP 4 R					
416	116 UP 11 R					
285 NW	30 UP 10 R					
285 NE						
285 SW						
285 SE						
218 I	0 UP 0 R					
218 O						
379 I	81 UP 18 L					
379 O						
375 I	80 UP 14 R					
375 O						

PLOT 3

Tree No.	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
514	4 UP 20 L					
516	15 UP 14 R					
530	27 UP 6 R					
540	18 UP 7 L					
545	23 UP 20 L					
550	29 UP 18 L					
564	47 UP 24 R					
566	48 UP 16 R					
587	60 UP 24 R					
601	80 UP 10 R					
603	84 UP 13 R					
612	89 UP 0 R					
613	97 UP 19 L					
614	84 UP 23 L					
618	111 UP 9 L					
620	105 UP 3 R					
621	120 UP 5 L					
624	135 UP 5 R					
626	122 UP 18 L					
627	129 UP 3 L					
513 NW	5 UP 16 L					
513 NE						
513 SW						
513 SE						
526 I	26 UP 17 R					
526 O						
605 I	87 UP 19 R					
605 O						
623 I	128 UP 2 R					
623 O						

PLOT 1 **Rain Collection Date: 1993** **Collected By:**

Tree	Type	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
1	O	0 UP 17 R					
7	P	1 UP 8 L					
8	F	1 UP 4 L					
9	O	2 UP 15 L					
15	P	8 UP 10 R					
16	P	8 UP 4 R					
18	P	8 UP 0 R					
22	P	8 UP 20 R					
27	F	13 UP 20 R					
30	P	11 UP 19 L					
32	O	13 UP 18 L					
36	O	16 UP 16 L					
40	O	18 UP 2 L					
44	O	23 UP 18 L					
46	O	24 UP 14 R					
47	P	30 UP 7 R					
48	O	36 UP 8 R					
53	F	33 UP 16 L					
54	F	34 UP 16 L					
57	F	37 UP 17 L					
67	P	43 UP 16 R					
70	F	46 UP 6 L					
72	P	53 UP 3 L					
73	P	57 UP 5 L					
76	P	56 UP 20 L					
77	P	63 UP 6 L					
80	F	65 UP 11 R					
83	O	71 UP 4 R					
86	O	74 UP 14 R					
98	P	91 UP 21 L					
113	F	89 UP 1 L					
126	F	96 UP 13 L					
127	F	96 UP 14 L					
169	P	7 UP 26 R					
178	P	88 UP 27 L					
92 NW	P	81 UP 21 L					
92 NE	P						
92 SW	P						
92 SE	P						
2 I	P	1 UP 11 R					
2 O							
69 I	P	48 UP 16 R					
69 O							
116 I	P	91 UP 5 L					
116 O							
170 I	P	29 UP 34 L					
170 O							
173 I	P	56 UP 29 R					
173 O							
177 I	P	51 UP 30 L					
177 O							
Stat I	P						
Stat O							

PLOT 2

Rain Collection Date: 1993 **Collected By:**

Tree	Type	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
204	P	4 UP 1 L					
206	O	5 UP 11 L					
208	O	6 UP 14 L					
214	F	8 UP 12 L					
217	P	8 UP 6 L					
228	P	8 UP 5 R					
230	O	9 UP 0 R					
234	P	12 UP 10 R					
235	O	12 UP 19 R					
241	P	16 UP 20 R					
242	P	16 UP 5 R					
243	O	15 UP 3 R					
253	P	12 UP 18 L					
261	F	16 UP 5 L					
263	P	16 UP 10 L					
270	P	19 UP 3 L					
277	O	20 UP 4 R					
278	P	21 UP 5 R					
283	O	28 UP 4 R					
289	P	36 UP 1 R					
291	P	25 UP 6 L					
336	F	38 UP 5 R					
340	F	38 UP 9 R					
342	P	47 UP 20 R					
348	F	46 UP 2 R					
353	O	55 UP 4 R					
359	F	62 UP 17 L					
361	F	66 UP 17 L					
366	P	68 UP 3 L					
368	P	69 UP 0 R					
377	P	83 UP 11 R					
383	P	84 UP 9 L					
387	F	84 UP 18 L					
399	O	91 UP 9 R					
414	P	115 UP 4 R					
416	P	116 UP 11 R					
423	F	117 UP 5 L					
285 NW	P	30 UP 10 R					
285 NE	P						
285 SW	P						
285 SE	P						
218 I	P	0 UP 0 R					
218 O							
225 I	P	9 UP 12 R					
225 O							
325 I	F	40 UP 15 L					
325 O							
339 I	O	38 UP 8 R					
339 O							
379 I	P	81 UP 18 L					
379 O							
375 I	P	80 UP 14 R					
375 O							

PLOT 3

Rain Collection Date: 1993 **Collected By:**

Tree	Type	Location	Triggered(Y/N)	Depth(in)	Initial	Final	Dilution
516		15 UP 14 R					
530		27 UP 6 R					
540		18 UP 7 L					
545		23 UP 20 L					
550		29 UP 18 L					
564		47 UP 24 R					
587		60 UP 24 R					
601		80 UP 10 R					
603		84 UP 13 R					
612		89 UP O R					
613		97 UP 19 L					
618		111 UP 9 L					
620		105 UP 3 R					
621		120 UP 5 L					
624		135 UP 5 R					
626		122 UP 18 L					
627		129 UP 3 L					
513	NW	5 UP 16 L					
513	NE						
513	SW						
513	SE						
514	I	4 UP 20 L					
514	O						
526	I	26 UP 17 R					
526	O						
566	I	48 UP 16 R					
566	O						
605	I	87 UP 19 R					
605	O						
614	I	84 UP 23 L					
614	O						
623	I	128 UP 2 R					
623	O						

1.0 **General Discussion**

Throughfall and open area rain and snow samples were collected from plots 1, 2, and 3 and the meterological station of the Barton Flats study area as outlined in RFL 08. These samples were analyzed for pH, chloride, nitrate, phosphate, sulfate, ammonium, calcium, magnesium, sodium, potassium and electrical conductivity as outlined below.

1.1 **Purpose of Procedure**

The purpose of the procedure was to compare the precipitation amounts and concentrations both within a plot and between plots. In addition, a comparison of precipitation amounts and elemental concentrations between collectors under canopies and outside of any canopy influence allows the quantification of the elemental amount rinsing off the canopies during a rain. The assumption is a majority of this material rinsing off the canopies is due to dry deposition to the foliage.

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 08	Rain and Throughfall Collection Method
LM 6.1	Measurement of pH
LM 6.2	Measurement of Electrical Conductivity
LM 6.3	Measurement of Low Level Anions - Dionex
LM 6.6	Measurement of Ammonium and Nitrate - TRAACS
LM 6.9	Measurement of Cations - Perkin Elmer 5000

2.0 **Apparatus**

1. Sartorius Analytical Balance
2. 15 ml centrifuge tubes
3. nanopure water

4.0 **Analytical Procedures**

Throughfall and rainfall samples were stored in the collector inner cylinders, sealed with parafilm, at 4° C until ready for processing. Samples were divided into two categories: those samples with greater than 0.13 inch sample and those less than 0.13 inch sample. Each sample greater than 0.13 inch sample was swirled to assure the materials on the cylinder walls came into solution. The samples was poured into a 15 ml centrifuge tube. The tube was filled to approximately 14 ml volume and the screw cap was attached. The remaining sample was stored in the inner collection cylinder, at 4° C, for pH analysis. Samples less than 0.13 inch were further categorized into those samples greater than 0.04 inch and those samples less than 0.04 inch. Each sample less than 0.04 inch was swirled, then poured into a tared, 15 ml centrifuge tube. The weight of the sample was determined using a Sartorius analytical balance and recorded. Nanopure water was added until the volume was approximately 14 ml. The total weight of the sample and dilution water was determined and recorded. Since no sample remained after the dilution process, no pH determination was possible. Each sample greater than 0.04 inch was swirled, then poured into a tared, 15 ml centrifuge tube to approximately 5 ml volume. The remainder of the sample was saved in the collector inner tube at 4° C for pH analysis. As described above, the sample was diluted with nanopure water and the dilution factor determined gravimetrically. The samples in the 15 ml tubes, which were frozen when not in use, were used for the analyses outlined below.

4.1 **pH Determinations**
The pH of each non-diluted sample was determined as outlined in LM SOP 6.1.

4.2 **Anion Determinations**
The concentrations of anions chloride, nitrate, phosphate and sulfate were determined using ion chromotography as outlined in LM SOP 6.3.

4.3 **Cation Determinations**
The concentrations of calcium, magnesium, sodium, and potassium were determined using atomic absorption spectrophotometry as outlined in LM SOP 6.9.

4.4 **Ammonium Determinations**
The concentrations of ammonium were determined using automated colorimetry as outlined in LM SOP 6.6.

4.5 **Electrical Conductivity Determinations**
On those samples having sufficient volume after pH determinations, the electrical conductivity was determined as outlined in LM SOP 6.2

5.0 **Quantification**
Dilution Factor:
Dilution factor = weight of sample / weight of sample and nanopure water
Dilution correction factor = 1 / Dilution factor

7.0 **References**
Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

1.0 General Discussion

1.1 Purpose of Procedure

Branch washing is used for determination of fluxes of various air-borne ions (mostly nitrate, sulfate and ammonium but also metallic cations) to forest canopies. This is important for calculating inputs of nutrients to forest stands, watersheds or ecosystems. In this study it is done on a vertical gradient (tower) and at a level of forest floor at three different research sites. Deposition fluxes are determined for three major tree species of the mixed coniferous forest ecosystem of the San Bernardino National Forest: ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), white fir (*Abies concolor* [Gord. & Glend.] Hildebr.), and black oak (*Quercus kelloggii* Newb.).

1.2 Measurement Principle

A branch on which air-borne substances are deposited over a given period of time is washed-out with deionized/distilled water. Concentrations of ions are determined in a washing solution, foliage surface area calculated, and time of the exposure recorded. Deposition fluxes of individual ions are calculated and expressed as mass of a given ion over unit of time and unit of surface area.

1.3 Measurement Interferences and Their Minimization

Measurements have to be done during periods of dry weather. Any rain, snow, or heavy fog precipitation, resulting in loss of deposited substances from branch surfaces prior to washing time has to be avoided. Excessive wind, and dust storms may affect the resulting determinations. Too long time of exposure could results in re-suspension of the deposited materials from foliar surfaces, excessive volatilization of those materials, or a possibility of their uptake by foliar interior. Too short time of exposure has to be avoided as well - too short time may not allow for accumulation of sufficient amount of airborne material on plant surface resulting in concentrations of ions in solution too low for accurate determinations.

1.4 Ranges and Typical Values of Measurements Obtained by the Procedure

For nitrate:	0.05 - 5.00	microequivalents m^{-2} h^{-1}
For ammonium:	0.05 - 2.50	"
For sulfate :	0.03 - 1.00	"

1.5 Typical Lower Quantifiable Limits, Precision, and Accuracy

Not tested.

1.6 Responsibilities of Personnel

A. Bytnerowicz, Bob Glaubig and Carl Tran are responsible for this work.

1.7 **Definitions**
Deposition flux - amount of material (ion) deposited on a known surface area in a unit of time.

1.8 **Related Procedures**
Determinations of concentrations of gaseous and particulate nitrogenous and sulfurous pollutants in air are done during the periods of collections of dry-deposited materials on branches. Such determinations are required for calculations of deposition velocities of various ions to plant surfaces.

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**
1. Polyethylene garden sprayer (e.g. Burgess Yard and garden Sprayer No. 7 or any similar type)
2. Nalgene 250 mL bottles
3. ice-chest with dry ice
4. plastic funnel of 16 cm diameter

2.2 **Reagents**
1. Deionized/distilled water, about 100 mL per sample

2.3 **Forms**
Information on branches (their numbers) and dates and time of pre-washing and final washing is logged into a laboratory book (no special forms provided). Before each time of sample collection, bottles are labelled in the chemical laboratory - labels contain sample field location of site, sample field number, and a period of exposure of branches to dry deposition.

4.0 **Procedures**

4.1 **General Flow Diagram**
1. Selection of appropriate branches. 2. Prewashing of branches. 3. Exposure of branches to dry deposition. 4. Rinsing-off deposited materials for branches. 5. Storage of samples on dry ice. 6. Transportation of samples to laboratory. 7. Storage of samples in -65°C. 8. Chemical analysis. 9. Determination of branch surfaces. 10. Calculation of deposition fluxes.

4.2 **Start-up**

4.3 **Routine Operations**
Branches of about 10 cm long, about 1 - 1.5 m above the ground level on a side of a tree facing incoming air masses are selected and tagged. In the beginning of the collection period the branches are thoroughly washed with deionized/distilled water dispersed from the gardening sprayer (about 200 mL per branch). Branches collect dry deposition for a period of 7 to 14 days. After that period the branches are placed over a plastic funnel connected with a 250 mL Nalgene bottle. The branches are thoroughly rinsed-off with about 125 mL deionized/distilled water. Immediately after washing is completed the bottles are tightly closed and placed on dry ice in an ice chest. Samples are transported immediately to the

laboratory and stored at -65°C until the analysis.

5.0 Quantification

Deposition flux (microequivalent m^{-2} h^{-1}) = volume of aliquot (L) * (concentration of sample - concentration of blank [microequivalent L^{-1}])/time (hours) * surface area (m^2)

6.0 Quality Control

Extreme caution is applied to handling branches collecting dry deposition. The branches are not touched during the collection period. The same applies to branch washing procedure - both during pre-washing and at the final washing, extreme precautions are undertaken to avoid contaminations of the samples (bottles and funnel are carefully washed; hands are kept away from inner surfaces of a funnel and bottle). Between collection and chemical analysis the samples are kept in low temperatures.

7.0 References

Bytnerowicz, A. P. R. Miller, and D. M. Olszyk. 1987. Dry deposition of nitrate, ammonium and sulfate to a Ceanothus crassifolius canopy and surrogate surfaces. Atmos. Environ., 21, 1749-1757.

Lindberg, S. E., and G. M. Lovett. 1985. Field measurements of particle dry deposition to foliage and inert surfaces in a forest canopy. Environ. Sci. Technol., 19, 238-244.

STANDARD OPERATING PROCEDURE
TITLE: Chemical Processing of Branch Washing Samples

PAGE: 1
DATE: 1-13-94
NUMBER: RFL 11

1.0 **General Discussion**

Branch washing samples of ponderosa pine, white fir, and black oak were collected as outlined in RFL 10. These samples were collected from both mature trees and potted seedlings located at plots 1, 2, 3 and the meteorological station of the Barton Flats study area. These samples were analyzed for chloride, nitrate, phosphate, sulfate, ammonium, calcium, magnesium, sodium, potassium, manganese and zinc.

1.1 **Purpose of Procedure**

The purpose of the procedure was to compare the elemental amounts rinsed from the tree foliage; the assumption was the majority of the removed elements were from dry deposition to the foliage. Comparisons were made within and between species, within and between locations, and within and between deposition years.

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 10	Branch Washing (Field Work)
LM 6.3	Measurement of Low Level Anions - Dionex
LM 6.6	Measurement of Ammonium and Nitrate - TRAACS 800
LM 6.9	Measurement of Cations - Perkin Elmer 5000

2.0 **Apparatus**

1. Sartorius top loader balance
2. Warm water bath

4.0 **Analytical Procedures**

Samples were stored frozen, in 250 ml bottles, until analyzed. Prior to analysis, the samples were thawed by placing the bottles in warm water. The thawed samples were brought up to 200 gram weight using a Sartorius top loader balance; those sample weights varying from 200 grams were recorded. The samples were well mixed.

4.2 **Anion Determinations**

The concentrations of anions chloride, nitrate, phosphate and sulfate were determined using ion chromotography as outlined in LM SOP 6.3.

4.3 **Cation Determinations**

The concentrations of calcium, magnesium, sodium, potassium, manganese and zinc were determined using atomic absorption spectrophotometry as outlined in LM SOP 6.9.

4.4 **Ammonium Determinations**

The concentrations of ammonium were determined using automated colorimetry as outlined in LM SOP 6.6.

7.0 **References**

Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

TITLE: Determination of Concentrations of Nitrogenous and Sulfurous Air Pollutants on a Vertical Gradient (Preparation of Systems and Field Work)

1.0 **General Discussion**

1.1 **Purpose of Procedure**

This procedure is used for determinations of concentrations of gaseous and particulate nitrogenous and sulfurous air pollutants within a mature canopy of a mixed coniferous forest.

1.2 **Measurement Principle**

Average 24-hour concentrations of nitric acid vapor, nitrous acid vapor, ammonia, sulfur dioxide, as well as particulate nitrate, ammonia, and sulfate are determined with annular denuder systems (Possanzini et al., 1983; Peake and Legge, 1987) through which the air is pulled at a constant flow rate of 17 l min^{-1}. This flow allows for quantitative determination of gaseous compounds deposited inside denuder tubes and ions in a fine fraction of particles (<2.2 micrometers) deposited on the Teflon and nylon filters.

1.3 **Measurement Interferences and Their Minimization**

Glass and Teflon parts of the denuder systems have to be thoroughly cleaned (detergent baths and thoroughly rinsing with deionized/distilled water before being coated with absorbing solutions. Any contamination of the reactive surface of the denuder tubes and filters during preparation of the systems should be avoided. Measurements should be performed during dry weather conditions. Duration of exposure of the systems to ambient air before and after air sample collections should be as short as possible. After the collections are made the systems should be moved to the laboratory as quickly as possible, disassembled and kept at -18°C prior to extraction and chemical analysis.

1.4 **Ranges and Typical Values of Measurements Obtained by the Procedure**

Nitric acid	0.2 - 20.0	microgram m^{-3}
Nitrous acid	0.0 - 2.0	"
Ammonia	0.2 - 6.0	"
Sulfur dioxide	0.1 - 3.0	"
Particulate nitrate	0.1 - 5.0	"
Particulate ammonium	0.0 - 1.5	"
Particulate sulfate	0.0 - 5.0	"

1.5 **Typical Quantifiable Limits, Precision, and Accuracy**

Not tested.

1.6 **Responsibilities and Personnel**
A. Bytnerowicz, Bob Glaubig and Carl Tran are responsible for this work.

1.7 **Definitions**
Annular denuder system - an apparatus consisting of a steady flow pump and a system of annular tubes connected with Teflon cyclone and filter holder used for determinations of concentrations of gaseous and particulate nitrogenous and sulfurous air pollutants.

1.8 **Related Procedures**
Branch washing used for determinations of ionic fluxes will be done at the same time as determinations of gaseous and particulate nitrogenous pollutants with annular denuder systems. This will allow for calculation of deposition velocities of major atmospheric species to plants surfaces.

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**

1. Annular denuder system (Kananaskis Air Pollution Systems)
2. Teflon tube caps (for coating and extraction of denuder tubes)
3. Clean-air chamber
4. Tank with ultrapure air
5. Anderson constant flow pumps (   )
6. Deep charge 12 V batteries

2.2 **Reagents**

1. Anion coating solution: 2% sodium carbonate and 2% glycerol in 1:1 nanopure water and methanol.
2. Transfer 1.0 g each of "Gold Label" sodium carbonate and "Gold Label" glycerol to a 50 mL volumetric flask. Dissolve in 25 mL nanopure water. Add methanol (99% pure) to 50 mL.
3. Ammonia coating solution: 2% citric acid and 2% glycerol in 1:1 nanopure water and methanol.
4. Transfer 1.0 g each of "Gold Label" citric acid and "Gold Label" glycerol to a 50 mL volumetric flask. Dissolve in 25 mL nanopure water. Add methanol (99% pure) to 50 mL.
5. Teflon 47 mm diameter filters (Zefluor, 2 micrometer pore size, Gelman Sciences Inc.).
6. Nylosorb 47 mm diameter filters (Nylasorb, 1 micrometer pore size, Gelman Sciences Inc.).

2.3 **Forms**
Information of annular denuder systems such as time of individual runs and field location of the samplers is recorded in a field book. No other forms are provided.

4.0 **Procedures**

4.1 **General Flow Diagram**
1. Washing and drying of Teflon and glass parts. 2. Coating of tubes with absorbing solutions. 3. Drying tubes in ultra clean chamber. 4. Assembling of the systems. 5. Air pollution

collection. 6. Transportation of systems to the laboratory. 7. Disassembling of systems. 8. Storage at -18°C.

4.2 Start-up

4.3 Routine Operations

All Teflon and glass parts of the systems are thoroughly washed and boiled in nanopure water for several hours and dried in a clean-air chamber. Tubes are dried with compressed ultrapure air (about 10 psi) prior to and after coating. The air is passed through a column of Drierite and a column of ascarite to remove impurities.

Anion and ammonia tubes are coated on the same day as they are loaded into the samplers. One tube end is filled with approximately 5 mL of a coating solution (anion or ammonia). A dried tube is inserted into the cap and another tube cap is placed on the top end of the tube. The tube is rotated several times such that an even coating is achieved. The tube caps are removed and the tube is drained of excess solution by standing in a test tube rack before drying (inside ultra clean chamber). Tubes are dried with compressed ultrapure air after coating. For each batch of tubes sent to the field, three anion and three ammonia blank tubes are prepared. The blank tubes are placed in clean plastic bags, tightly sealed and placed in a freezer (-18°C). These blanks are extracted and analyzed together with the field samples.

Systems are assembled by connecting Teflon cyclone with two anion tubes, one ammonia tube, and a filter holder containing a Teflon and nylon filter. Both ends of the systems are sealed with Parafilm.

In the field the systems are connected to the steady flow Andersen pumps. Systems are run at 17 l min^{-1} flow rate for 24 hours. After air pollution collection a flow rate is re-checked and recorded together with duration of a collection. The systems are disconnected from the pumps and both of their ends are sealed with Parafilm. The systems are moved to the laboratory immediately after the collection and disassembled. Tubes are placed in clean plastic bags, sealed and labelled. Teflon and nylon filters are placed in polycarbonate Petri dishes and sealed in plastic bags. Both tubes and filters are kept in a freezer (-18°C) prior to extractions and analysis.

5.0 Quantification

Concentration of a pollutant (micrograms m^{-3}) = (concentration of sample - concentration of blank [milligrams L^{-1}]) * volume of sample (L) * 1000 / (flow [L min^{-1}] * time [min] / 1000)

6.0 **Quality Control**

Extreme caution should be applied during preparation of the annular denuder systems, setting and maintaining required air flow through the systems, and recording the flow rates and time of exposures. All the solutions are prepared from "Gold Label" grade chemicals and a sufficient number of blank samples is used for each series of the annular denuder runs.

7.0 **References**

Peake, E., and A. H. Legge. 1987. Evaluation of methods used to collect air quality data at remote and rural sites in Alberta, Canada. EPA/APCA Symposium "Measurement of Toxic and Related Air Pollutants", Research Triangle Park, NC, May 3-6, 1987.

Possanzini, M., A. Febo, and A. Liberti. 1983. New design of a high performance denuder for the sampling of atmospheric pollutants. Atmos. Environ., 17, 2605-2610.

STANDARD OPERATING PROCEDURE
TITLE: Chemical Processing of Kananaskis Atmospheric Pollutant Sampler (KAPS) Samples

PAGE: 1
DATE: 1-13-94
NUMBER: RFL 13

1.0 **General Discussion**

Kananaskis Atmospheric Pollutant Samplers (KAPS) were operated at several times between May and October at plot 2 and the meteorological station; as outlined in RFL 12. Each KAPS apparatus was returned to the laboratory shortly after the run was completed, and the collection tubes and filters were extracted and analyzed for ammonium, nitrate, nitrite, and sulfate. These analyses determined both gaseous and particulate forms of the compounds captured by the KAPS apparatus.

1.1 **Purpose of Procedure**

The purpose of the procedure was to determine the amount and form of atmospheric pollutants found in the Barton Flats study area. Comparisons were made within and between locations and between vertical heights on the tower. In addition, results at different sampling times were compared, both within and between years.

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 12	Determination of Concentrations of Nitrogenous and Sulfurous Air Pollutants on a Vertical Gradient (Preparation of Systems and Field Work)
LM 6.3	Measurement of Low Level Anions - Dionex
LM 6.6	Measurement of Ammonium and Nitrate - TRAACS 800

4.0 **Analytical Procedures**

The KAPS apparatus is a unit designed by and commercially available from the Kananaskis Centre For Environmental Research, Calgary, Alberta, Canada. Many of the following procedures will be referenced to the instruction manual received with the units.

Shortly after each KAPS run was complete, each KAPS apparatus was returned to the laboratory. Each apparatus was disassembled as outlined in KAPS Manual, section 2, figure 1. The two anion annular denuder tubes and one ammonium annular denuder tube were carefully removed, and each was sealed in a separate plastic bag. The teflon and nylon filters were carefully removed from the filter pack, and each was sealed in a petri dish. The plastic bags and petri dishes containing samples were frozen until extraction.

4.1 **Extractions**

The elements were extracted from the annular denuder tubes and filters using one of three different procedures.

4.1.1 Anion Annular Denuder Tube Extractions

The two anion tubes were each warmed to room temperature and extracted with 10.0 ml of sodium bicarbonate/ carbonate solution as outlined in KAPS Manual, appendix A, section 2.3.

4.1.2 Ammonium Annular Denuder Tube Extractions

Each ammonium tube was warmed to room temperature and extracted with 10.0 ml of nanopure water as outlined in KAPS Manual, appendix A, section 2.3.

4.1.3 Filter Extractions
The teflon and nylon filters were warmed to room temperature and extracted with 50.0 ml of sodium bicarbonate/carbonate solution as outlined in KAPS Manual, appendix A, section 3.0. Each filter was placed into a 300 ml erlynmeyer flask. A 50.0 ml aliquot of extracting solution was added, the flask was sealed with parafilm and placed on a wrist action shaker for 15 minutes.

4.2 **Anion Determinations**

4.2.1 Anion Tube Extraction Samples
The concentrations of anions nitrate, nitrite and sulfate were determined in samples extracted in 4.1.1 using ion chromotography as outlined in LM SOP 6.3.

4.2.2 Filter Extraction Samples
The concentrations of anions nitrate and sulfate were determined in samples extracted in 4.1.3 using ion chromotography as outlined in LM SOP 6.3.

4.4 **Ammonium Determinations**

4.4.1 Ammonium Tube Extraction Samples
The concentrations of ammonium were determined in samples extracted in 4.1.2 using automated colorimetry as outlined in LM SOP 6.6.

4.4.2 Filter Extraction Samples
The concentrations of ammonium were determined in samples extracted in 4.1.3 using automated colorimetry as outlined in LM SOP 6.6.

5.0 **Quantification**
The following calculations are used for determining final concentrations of atmospheric pollutants.

Gaseous Ions:

$$\text{Final conc} = \frac{(\text{conc sample} - \text{conc blank}) \times \text{extract volume}}{\text{flow} \times \text{duration} / 1000} \times \text{coff factor}$$

where: Final conc is in ug/m^3
conc sample is in mg/l
conc blank is in mg/l
extract volume is in ml
flow is in liters/min
duration is in min

corr factors	NO_2 to HNO_2	1.022
	NO_3 to HNO_3	1.016
	SO_4 to SO_2	0.667
	NH_4 to NH_3	0.944

Particulate Ions:

$$\text{Final conc} = \frac{(\text{conc sample} - \text{conc blank}) \times \text{extract volume}}{\text{flow} \times \text{duration} / 1000}$$

where: Final conc is in ug/m^3
conc sample is in mg/l
conc blank is in mg/l
extract volume is in ml
flow is in liters/min
duration is in min

7.0 **References**

KAPS Manual. Kananaskis Centre For Environmental Research. University of Calgary. Calgary, Alberta, Canada.

Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

1.0 **General Discussion**

Soil pits, for determination of soil horizon depth, characteristics, and collection of samples, were dug in plots 1, 2, and 3 of the Barton Flats study area.

1.1 **Purpose of Procedure**

The purpose of the soil pits was to characterize the soils within each plot, and compare the soil horizon characteristics, both within and between plots. The locations of the soil pits were chosen in areas representative of each plot; areas well represented by the three plant species: ponderosa pine, white fir, and black oak.

1.2 **Schedule**

Five soil pits per plot were located, prepared (dug), and sampled according to the following schedule:

Plot 1:	Pit A, Pit B	Sept 26, 1991
	Pit C, Pit D, Pit E	October 01, 1991
Plot 2:	Pit A	Sept 26, 1991
	Pit C, Pit D	October 01, 1991
	Pit E, Pit F	October 16, 1991
Plot 3:	Pit A, Pit B, Pit C, Pit D, Pit E	October 09, 1991

1.3 **Soil Pit Locations**

Soil pit locations were chosen around the perimeter of each plot. Locations were identified by referencing nearby trees or plot stakes within each plot; outside refers to away from center line; inside refers to towards center line. Refer to RFL 22 for specific tree locations.

Plot 1:
Pit A 50 m above, 50 m east of top of plot center line stake.
Pit B 12 m outside tree 68; on tree 68 perpendicular
Pit C 7 m outside tree 170, 6 m above tree 170 perpendicular
Pit D 14 m outside tree 98, 2 m above tree 98 perpendicular
Pit E 8 m outside tree 27, on tree 27 perpendicular

Plot 2:
Pit A 18 m below, 30 m north of top of plot center line stake
Pit C 10 m outside tree 375, 1 m below tree 375 perpendicular
Pit D 5 m outside tree 287, on tree 287 perpendicular
Pit E 11 m outside tree 369, 2 m above tree 369 perpendicular
Pit F 7 m above top of plot stake, on center line extension

Plot 3:
Pit A 5 m outside tree 526, 2 m above tree 526 perpendicular
Pit B 6 m outside tree 605, 2 m above tree 605 perpendicular
Pit C 27 m west of top of plot stake, 2 m below stake perpendicular
Pit D 34 m east of center line, 6 m below 120 m stake perpendicular
Pit E 14 m outside tree 558, 2 m below tree 558 perpendicular

1.8 **Related Procedure List**

Standard Operating Procedures:
RFL 15 Chemical Processing of Soil Pit Samples

2.0 **Apparatus**

1. Tools: Long handled shovel
   Pick ax
   Meter stick
   Tape measure
   Sample bags
   Trowel
   Bulk density constant volume corer
2. Tree location list

4.0 **Procedures**

4.3 **Soil Pit Preparation**

Soil pits were dug with a shovel and pick ax until no further horizon differentiations were seen; this was usually down to a depth of 0.5 m or more. As the pits were dug, a visual estimate of the percentage (recorded to the nearest 5%) of rocks and stones present was made. Once the pit was dug to the appropriate depth, several smooth faces on one of the walls were created using a shovel. At these faces, the thickness and depth of each horizon, both organic and mineral, were measured. The average thickness and depth of each horizon were recorded. Samples of each horizon were collected using a hand trowel; these samples were placed in labeled, plastic bags. At each mineral horizon, a sample for bulk density was taken using a constant volume corer and placed in a labeled, plastic bag. After the information and samples were collected, each soil pit was filled in with the excavation soil and covered with surrounding litter.

7.0 **References**

1.0 **General Discussion**
The organic and mineral soil samples collected from the five soil pits in each of the three plots at the Barton Flats study area, as outlined in RFL 14, were processed and analyzed for the following components and characteristics: bulk density, texture, pH, extractable cations, cation exchange capacity, color, total nitrogen and total carbon.

1.1 **Purpose of Procedure**
The purpose of analyzing the soil pit samples was to compare the soil characteristics, both within each plot and between plots. This allowed conclusions to be made on the similarity of the three plots and the spatial variability present within plots.

1.8 Related Procedure List
Standard Operating Procedures:

RFL 14	Soil Pit Location, Preparation, and Sampling
LM 2.1	Sample Grinding
LM 2.13	Elemental Combustion Analysis: Plant Tissue
LM 4.3	Shatterboxing
LM 4.6	Particle Size Analysis: Hydrometer Method
LM 5.1	Measurement of pH: 0.01 M $CaCl_2$
LM 5.13	Elemental Combustion Analysis: Soil
LM 5.3	Measurement of Extractable Bases/Cation Exchange Capacity ($SrCl_2$)

2.0 **Apparatus**
1. Sartorius top loader balance
2. 2 mm square hole sieve
3. 105° oven

4.0 **Procedures**

4.1 **Bulk Density Sample**
A soil sample was taken for bulk density determination from each mineral horizon of every soil pit at each of the three plots. These bulk density soil samples were stored at 4° C while not being used. A sub-sampling of each sample was taken for each analysis.

4.1.1 Bulk Density/Texture Determinations
The samples collected for bulk density determination were oven dried at 105° C for a minimum of 24 hours. Each sample was removed from the oven and placed in a dessicator until cool. The sample weight was determined using a Sartorius top loader balance. The assigned volume of the bulk density probe was 231 cubic centimeters. Each sample was passed through a 2 mm, square hole sieve; if aggregates were present the sample was lightly crushed in the sieve using a pestle. The weights of the greater than 2 mm and less than 2 mm portions of the soil were determined using a Sartorius top loader balance; the weights were recorded. The greater than 2 mm portion was saved for future analyses. The texture of the less than 2 mm portion

of the sample was determined following LM SOP 4.6; the pretreatment procedure (LM SOP 4.6.3.1) was not performed; 40.0 g of soil were used.

4.2 **Organic Analytical Sample**

An organic soil sample was taken from each organic horizon of every soil pit from each of the three plots. These samples were stored at 4° C when not in use. The entire sample was ground to pass a 20 mesh sieve as outlined in LM SOP 2.1.

4.2.1 Total Nitrogen and Carbon Determinations

Total nitrogen and carbon concentrations in the organic samples were determined as outlined in LM SOP 2.13.

4.3 **Mineral Analytical Sample**

A mineral soil sample was taken from each mineral horizon of every soil pit from each of the three plots. The samples were stored at 4° C when not in use. The entire sample was passed through a 2 mm square hole sieve. The portion greater than 2 mm was discarded. The portion less than 2 mm was used for analysis of the following components.

4.3.1 Total Nitrogen and Carbon Determinations

A sub-sample of the less than 2 mm soil was shatterboxed as outlined in LM SOP 4.3. Total nitrogen and carbon concentrations in the mineral soil samples were determined as outlined in LM SOP 5.13.

4.3.2 pH Determinations

The pH of each mineral soil horizon was determined in 0.01 M $CaCl_2$ as outlined in LM SOP 5.1.

4.3.3 Extractable Cations/Cation Exchange Capacity Determinations

Extractable cations calcium, magnesium, sodium and potassium were extracted using 1.0 M strontium chloride as outlined in LM SOP 5.3.

4.3.4 Color Determinations

Air-dry sub-samples of the non-sieved soils were used to determine soil color. The soils were placed in direct sunlight and the colors determined by comparison with the Munsell Soil Color Charts.

5.0 **Quantification**

Bulk density calculation:

bulk density = soil oven dry weight / 231

bulk density is in g/cc
soil oven dry weight is in g
231 represents the assigned volume of the bulk density probe in cc

7.0 **References**

1975. Munsell Soil Color Charts. Macbeth Division/Kollmorgen Corp. Baltimore, Maryland.

Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service

1.0 **General Discussion**

At each of the three plots of the Barton Flats study site, soil and litter samples were collected from under fifty individual Ponderosa pine trees. At each tree, a composite sample of three locations under that tree was collected for the O1, O2, and A Horizon. All samples were analyzed for total nitrogen and carbon, and soil samples were also analyzed for extractable cations and cation exchange capacity.

1.1 **Purpose of Procedure**

The purpose of the procedure was to compare the elemental concentrations and characteristics of soils and litter both within and between plots, and as a baseline to compare with collections occurring in different years.

1.2 **Schedule**

All individual tree soil and litter samples were collected during November 1991.

1.3 **Sampling Locations**

Locations of individual trees are found in RFL 22. At each tree, three sampling locations were chosen. These were located at a distance equal to 1/2 the canopy radius away from the tree trunk. The sampling locations were chosen on three lines away from the tree; one on the perpendicular to the plot center line, the other two lines were 120° away from the centerline perdendicular. The distances determined for 1/2 canopy radius were measured and recorded. The soil and litter from fifty three trees were sampled at plot 1, fifty trees from plot 2, and forty eight trees from plot 3.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 17 Chemical Processing of Individual Tree Soil and Litter Samples

RFL 22 Needle and Leaf Litter Collection and Weighing

2.0 **Apparatus**

1. Tools:
   - Tape measure
   - 12 inch nails for temporary sample location marking
   - Sample Bags
   - Hand trowel
2. Tree location list

4.0 **Procedures**

Individual trees were located using the location list outlined in RFL 22. Once trees were found, the three sampling directions were determined as outlined in section 1.3. A visual estimate of the 1/2 canopy radius was made, and that distance was measured. Along each direction, a distance equal to 1/2 canopy radius was measured away from the tree trunk and a 12 inch nail was inserted to mark the location. One individual would gather O1 and O2 samples from each of the sampling locations. All the O1 samples were composited into one sample; all the O2 samples were composited into one sample. A second individual would follow and sample the top 2 cm of soil, using a hand trowel, at the same three sample locations; again the three soil samples were composited into one sample. Each plastic bag containing samples was marked with sample date, tree number, and horizon. Samples were stored at 4°C until analyzed.

7.0 **References**

1.0 **General Discussion**

The soil and litter samples collected from the individual trees in each of the three plots at the Barton Flats study area, as outlined in RFL 16, were processed and analyzed for total nitrogen and carbon. In addition, the soil samples were also analyzed for extractable cations and cation exchange capacity.

1.1 **Purpose of Procedure**

The purpose of analyzing the soil and litter from under individual trees was to compare the components and characteristics, both within each plot and between plots. This allowed conclusions to be made on the similarity of the three plots and the spatial variability present within plots. In addition, this information will serve as baseline to compare with future samplings at this site.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 16	Sampling of Individual Tree Soils and Litters
LM 2.1	Sample Grinding
LM 2.13	Elemental Combustion Analysis: Plant Tissue
LM 4.3	Shatterboxing
LM 5.13	Elemental Combustion Analysis: Soil
LM 5.3	Measurement of Extractable Bases/Cation Exchange Capacity ($SrCl_2$)

2.0 **Apparatus**

1. 2 mm square hole sieve
2. 105° oven

4.0 **Procedures**

4.2 **O1 and O2 Horizon Analytical Samples**

The litter samples taken from the O1 and O2 horizons were stored at 4° C when not in use. The entire sample was oven dried at 70°C and ground to pass a 20 mesh sieve as outlined in LM SOP 2.1.

4.2.1 Total Nitrogen and Carbon Determinations

Total nitrogen and carbon concentrations in the litter samples were determined as outlined in LM SOP 2.13.

4.3 **Mineral Analytical Sample**

The A horizon soil samples were stored at 4° C when not in use. The entire sample was oven dried at 70°C and passed through a 2 mm square hole sieve. The portion greater than 2 mm was discarded. The portion less than 2 mm was used for analysis of the following components.

4.3.1 Total Nitrogen and Carbon Determinations

A sub-sample of the less than 2 mm soil was shatterboxed as outlined in LM SOP 4.3. Total nitrogen and carbon concentrations in the mineral soil samples were determined as outlined in LM SOP 5.13.

4.3.3 Extractable Cations/Cation Exchange Capacity Determinations

Extractable cations calcium, magnesium, sodium and potassium were extracted using 1.0 M strontium chloride as outlined in LM SOP 5.3.

7.0 References

Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

1.0 **General Discussion**

At plot 2 of the Barton Flats study site, ten ceramic mini-lysimeters were installed to be used for extracting soil solutions. The lysimeters were installed in pairs; one of each pair in the A soil horizon and one in the B soil horizon. Four of the lysimeter pairs were located under trees, while the remaining lysimeter pair was located in the open.

1.1 **Purpose of Procedure**

The purpose of the procedure was to extract soil solution samples which would be analyzed for chemical composition. These soil solution chemical concentrations would be used as a component in the NuCM model and as a consideration in the throughfall/rain mass balance and nutrient loading determinations.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 19 Chemical Processing of Soil Solution Samples

2.0 **Apparatus**

1. Tools:
   - Tape measure
   - 10 ceramic lysimeters
   - Soil Probe
   - 12 volt vacuum pump w/250 ml erlynmeyer flask extraction apparatus
2. Tree location list

4.0 **Procedures**

4.1 **Lysimeter Construction/Preparation**

The ten ceramic mini-lysimeters were constructed as outlined in Grulke et. al, 1987. Prior to use, each lysimeter was rinsed by drawing 250 ml of nanopure water through the unit; the resulting solution was tested for electrical conductivity to assure the units were clean.

4.2 **Lysimeter Installation**

Each lysimeter was constructed and cleaned as outlined in section 4.1. The lysimeters were installed in pairs, one in the A soil horizon and the other in the B soil horizon. Since the depth of the A/B horizon boundry varied throughout the plot, the installation depths varied. At each installation site, a soil probe was used to determine the depth of the A/B horizon boundry. The A horizon lysimeters were installed with the bottom of the ceramic cup 2 to 3 cm above the horizon boundry; the B horizon lysimeters were installed with the top of the ceramic cup 2 to 3 cm below the boundry. The soil probe was used to core out the soil to the proper depth for each lysimeter installation. Once installed, each lysimeter was backfilled with soil and lightly packed. The installation locations were as follows:

Site 1 2 m left of tree 206
Site 2 1 m left of tree 241
Site 3 2 m below tree 414

Site 4 3 m below, 1 m left of tree 348
Site 5 Next to rain collector 375 O; not under any tree canopy

Locations left or right refer to direction while looking uphill.

4.3 **Lysimeter Operation**

At each sampling, a 12 volt DC pump was used to extract the soil solutions; each lysimeter was extracted individually. The vacuum pump apparatus consisted of one deep discharge marine battery, 12 volt pump, and 250 ml erlynmeyer flask attached to a 1/8 inch teflon line. A 15 ml polypropylene centrifuge tube was placed into the erlynmeyer flask to catch the extracting soil solution. The 1/8 teflon line from the erlynmeyer flask was attached to the 1/8 inch line from the lysimeter. The vacuum was run until 15 ml of soil solution had been collected or for 2 hours.

7.0 **References**

Grulke, N.E., G.H. Reichers, U. Hjelm, and W.C. Oechel (1987). Response of a Tundra Ecosystem to Elevated Atmospheric Carbon Dioxide. Progress Report. U.S. DOE, Office of Basic Energy Sciences, Carbon Dioxide Research Division, # DE-FG03-86ER60479. Pg 15.

1.0 **General Discussion**
Soil solution samples were extracted from ceramic mini-lysimeters located at plot 2 of the Barton Flats study area. These samples were analyzed for pH, chloride, nitrate, phosphate, sulfate, ammonium, calcium, magnesium, sodium, and potassium.

1.1 **Purpose of Procedure**
The purpose of the procedure was to compare the elemental concentrations extracted from the soil, both within and between horizons, and between lysimeter locations. Comparisons were made between data collected in different years.

1.8 **Related Procedures**
Standard Operating Procedures:

RFL 18	Placement and Operation of Soil Solution Samplers
LM 6.1	Measurement of pH
LM 6.3	Measurement of Low Level Anions - Dionex
LM 6.6	Measurement of Ammonium and Nitrate - TRAACS 800
LM 6.9	Measurement of Cations - Perkin Elmer 5000

2.0 **Apparatus**
1. Warm water bath

4.0 **Analytical Procedures**
Samples were stored frozen, in 15 ml centrifuge tubes, until analyzed. Prior to analysis, the samples were thawed by placing the centrifuge tube in warm water.

4.1 **pH Determinations**
The pH of the samples was determined using a pH meter as outlined in LM SOP 6.1.

4.2 **Anion Determinations**
The concentrations of anions chloride, nitrate, phosphate and sulfate were determined using ion chromotography as outlined in LM SOP 6.3.

4.3 **Cation Determinations**
The concentrations of calcium, magnesium, sodium, potassium, manganese and zinc were determined using atomic absorption spectrophotometry as outlined in LM SOP 6.9.

4.4 **Ammonium Determinations**
The concentrations of ammonium were determined using automated colorimetry as outlined in LM SOP 6.6.

7.0 **References**
Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

1.0 **General Discussion**

1.1 **Purpose of Procedure**

The purpose of this standard operating procedure is to describe the materials needed and methods to employ to create an inexpensive, easily constructed litter collector capable of trapping deposited litter and prohibiting removal during adverse conditions.

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 21	Placement of Litter Collectors
RFL 22	Needle and Leaf Litter Collection and Weighing
RFL 23	Chemical Processing of Needle and Leaf Litter Samples

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**

2.1.1 Description

The litter collector is designed to be rugged enough to withstand many seasons in the field under adverse conditions and still inexpensive enough to be manufactured in numerous quantities to facilitate larger sampling areas. The collector is constructed of commercially available lumber which is then treated with a commercial water sealant and painted in a camouflage design to make it impervious to water and less noticeable to passers-by. The collector stands approximately 152 mm off of the forest floor with a 502 mm square opening equipped with a mesh bottom to allow the capture of litter without the excess buildup of other dirt and debris.

2.1.2 Maintenance

The only maintenance for the litter collectors are the occasional repairs required due to inquisitive woodland and urban creatures.

2.2 **Supplies**

A. wall, 2 - 19 mm thick, 89 mm wide, 502 mm long [cut from a 19
x 89 x 3048 mm piece of pine wood (sold commercially as a 10 foot length of 1 x 4 inch piece of pine.)]

B. wall, 2 - 19 mm thick, 89 mm wide, 540 mm long [cut from a 19
x 89 x 3048 mm piece of pine wood (sold commercially as a 10 foot length of 1 x 4 inch piece of pine.)]

C. corner brace, 4 - 13 mm thick, 102 x 102 x 144 mm triangle [cut from a 1219 x 2438 mm (4 x 8 foot) sheet of 13 mm (3/8 inch) thick sheet of CDX grade plywood.

D. EMT (electrical conduit) clamps, 8 - 13 mm (1/2 inch)

E. fine meshed screen, 1 - 540 x 540 mm square

F. drywall screws, 8 - 51 x 2.4 mm (2 inches long)

G. drywall screws, 32 - 25 x 2.4 mm (1 inch long)

H. legs, 4 - wood dowel 19 mm diameter, 760 mm long

I. screwdriver

J. drill with 1.5 mm wide drill bit
K. staple gun with 9.5 mm (3/8 inch) staples
L. carpenter's glue
M. water sealant (Thompsons)

4.0 **Procedures**

4.1 **Construction**

To aid in the construction of the litter collector, figures 1, 2, and 3 have been attached giving detailed views of the litter collector design. It is necessary to drill 1.5 mm pilot holes for all of the drywall screws used in the construction to prevent the wood from splitting. It is also recommended to use carpenter's glue wherever any wooden surfaces are being joined together to increase strength, although this measure is not absolutely necessary.

The box of the litter collector was constructed by attaching the 502 mm walls (A) inside of the 540 mm walls (B) using the 51 mm drywall screws (F). The corner braces (C) were then attached to the underside of the collector in each of the respective corners using four 25 mm drywall screws (G). This provides a sturdy frame which is the main body of the litter collector.

The legs (H) are attached next and are held to the side of the frame using the 13 mm EMT clamps (D). These clamps are attached using the 25 mm drywall screws (G). Attach the clamps so that one end is screwed into the end of wall B and the other end is screwed into the side of wall A. This will provide an added measure of strength by forcing the clamps to hold the walls together along with the corner braces.

Finally, attach the fine meshed screen (E) to the bottom of the collector. Mold the screen around the corner braces to eliminate any openings and, using the staple gun and 9.5 mm staples, staple the screen to the bottom of the collector. Allow the screen to sag down slightly from the collector to prevent the screen from being too tight and having litter bounce out of the collector.
Another method for attaching the screen would be to place it between the four corner braces and the bottom of the walls. This would allow the screen to lie flat and would further eliminate gaps. However, this method is much more cumbersome because the corner braces would need to be removed if it became necessary to replace the screen. Either method may be employed depending on the preference of the user.

7.0 **References**

Figure 1. Top View of the Litter Collector.

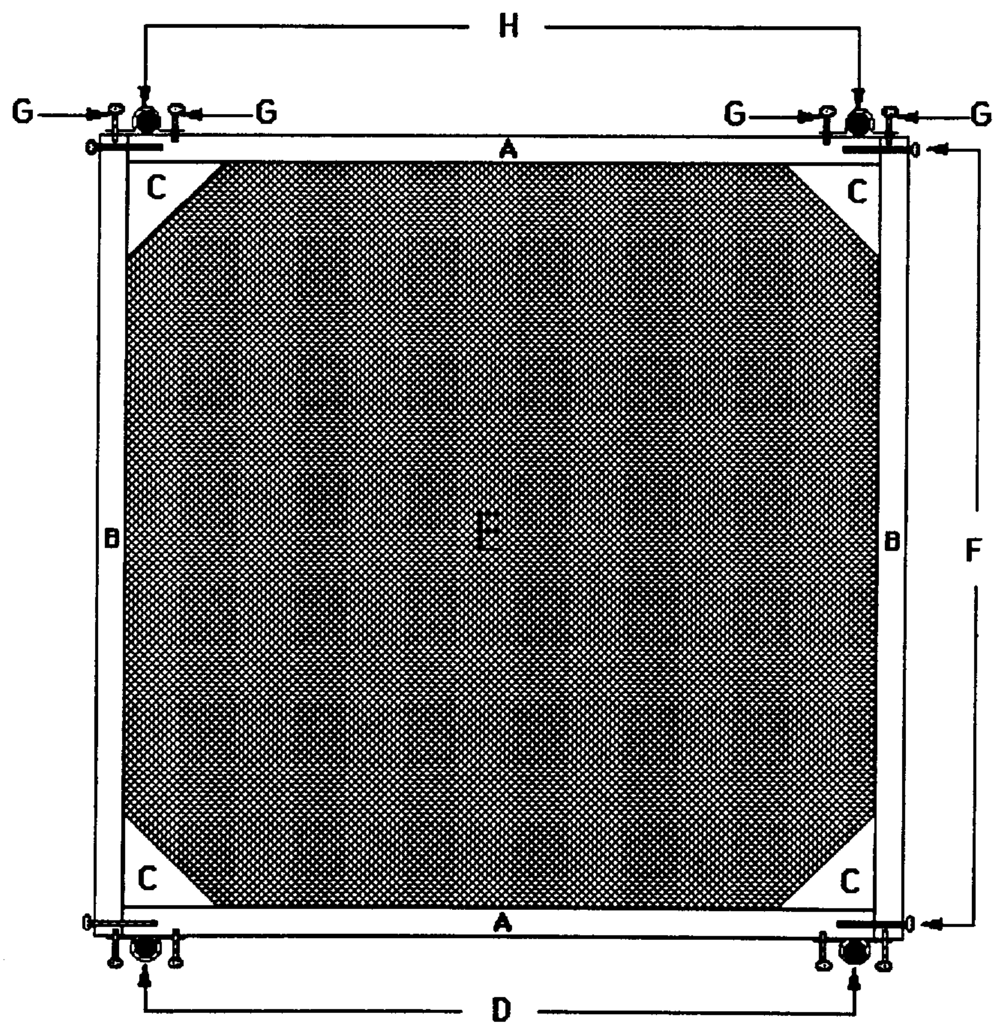


Figure 2. Bottom View of the Litter Collector.

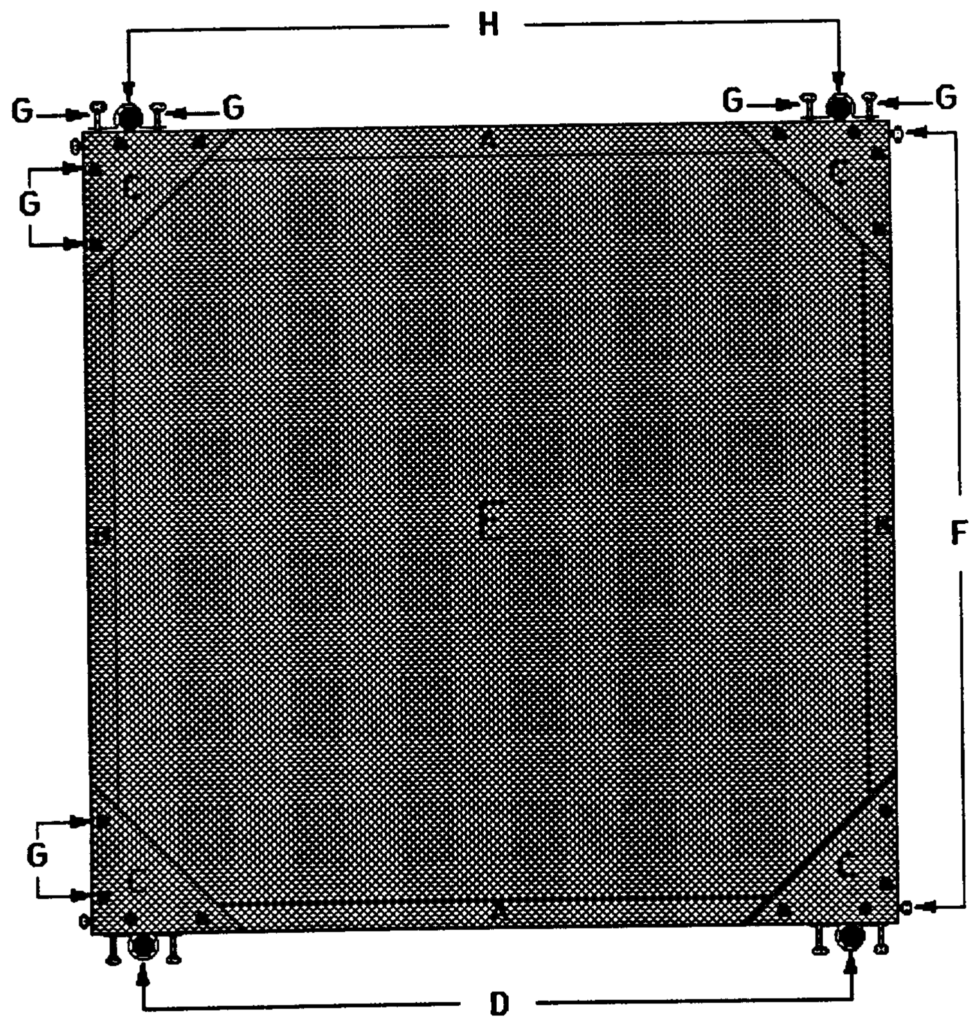
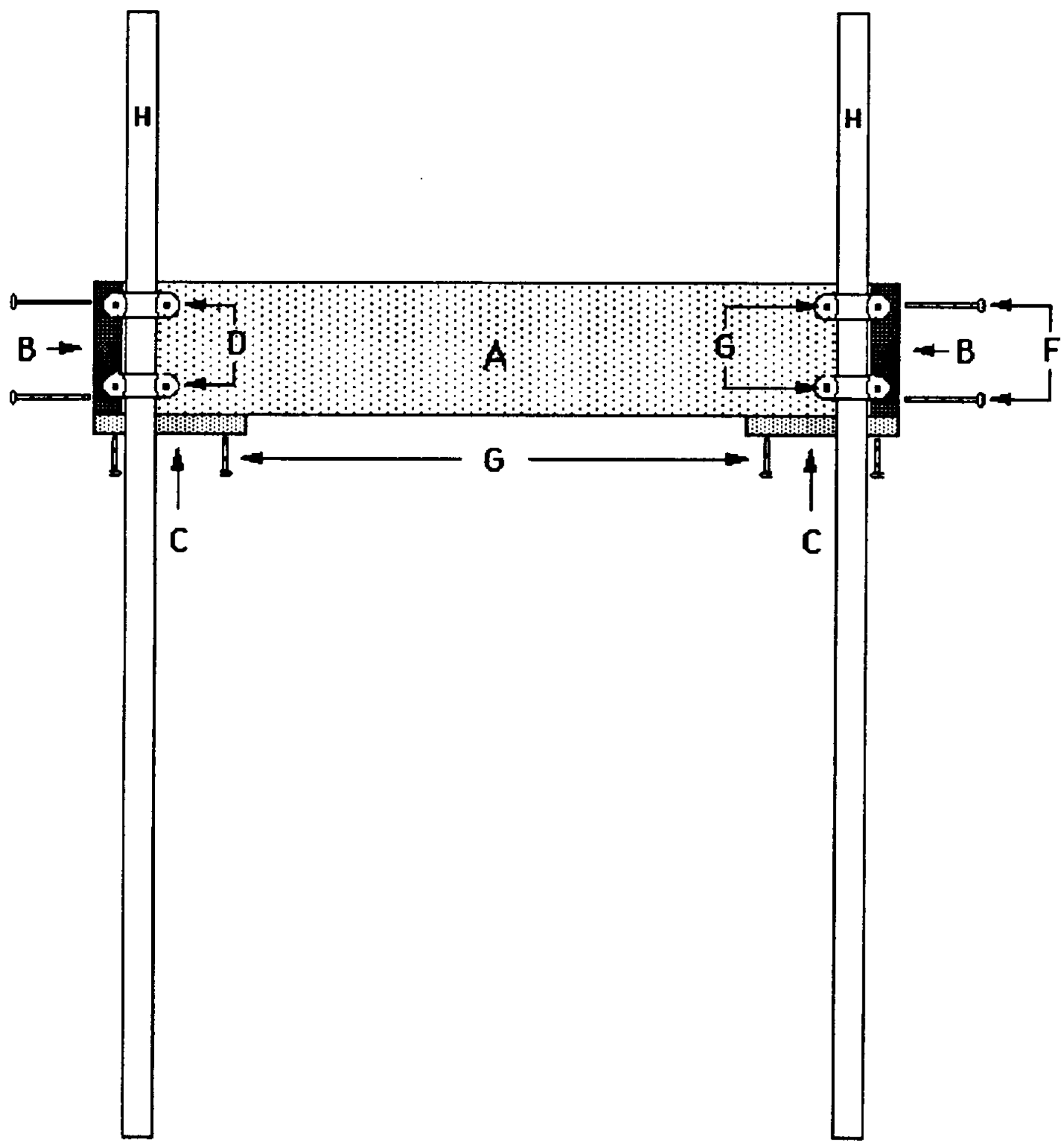


Figure 3. Side View of the Litter Collector.



1.0 **General Discussion**

Litter collectors, construction described in RFL 20, were placed in plots 1, 2, and 3 of the Barton Flats study area. The litter collectors were placed under the canopies of ponderosa pine, white fir, and black oak trees to catch falling needles and leaves.

1.1 **Purpose of Procedure**

The purpose of placing the litter collectors was to determine both the weight and element concentrations of the needle/leaf litter, to help in developing a nutrient budget for the study area. The litter amounts and element concentrations were compared within and between plots, within and between species, and between different years of collections.

1.2 **Placement Schedule**

Spring 1992	All Plots	30 litter collectors were placed under ponderosa pines
Spring 1993	Plots 1, 2	10 litter collectors were placed under black oak canopies 10 litter collectors were placed under white fir canopies
Spring 1994	All plots	No change

The exact trees used during each year can be found in RFL 22

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 20 Construction of Litter Collectors
RFL 22 Needle and Leaf Litter Collection and Weighing

2.0 **Apparatus**

1. Collectors w/four legs
2. Tools:
   - Hammer
   - String Level
   - Socket
   - Screw drivers - crosshead and flathead
   - Pliers
   - Loppers
   - Meter stick
   - Compass
3. Tree location list

4.0 **Procedures**

4.3 **Placement Procedure**

On one ponderosa pine at each plot, four litter collectors were placed away from the trunk in the north, south, east, and west directions. The litter collector locations around other trees were chosen to maximize the canopy above it while minimizing the canopies of other species; compass direction from the tree was not considered. Each collector was placed with the outside edge 1.0 to 1.2 meters away from the tree trunk. Once the location of each collector was chosen, the four legs were installed in the collectors, and the leg screws were tightened. Loppers were used to visually level each collector by cutting the length of one or more legs. Once level, the legs were pounded into the ground.

4.4 **Winterization**

Between each collection season, the collectors were left in the field for the winter. No winterization procedures were taken.

7.0 **References**

1.0 **General Discussion**
This document provides procedures for the collecting, processing and validation of ponderosa pine needle litter data from the ARB Barton Flats field plots. It describes collection of data in the field and integration into the database.

1.1 **Purpose of Procedure**

1.2 **Measurement Principle**

1.3 **Measurement Interferences and their Minimization**

1.4 **Ranges and Typical Values of Measurement obtained by this procedure**

1.5 **Typical Lower Quantifiable Limits, Precision, and Accuracy**

1.6 **Responsibilities of Personnel**
The field technician is responsible for visiting each litter collector, counting the needles or bagging them in a labeled paper bag and delivering the bags and/or the field data sheet to the lab. The lab technician is responsible for weighing and counting the needles and entering the data on the field data sheet. The database manager integrates the data into the database.

1.8 **Related Procedures**
Standard Operating Procedures:
- RFL 20 Construction of Litter Collectors
- RFL 21 Placement of Litter Collectors
- RFL 23 Chemical Processing of Needle and Leaf Litter Samples

2.0 **Apparatus, Instrumentation, Reagents, and Forms**

2.1 **Apparatus and Instrumentation**
1. Litter collectors
2. Sartorius Model 1601 Analytical Balance or Model 1213 Top Load Balance
3. IBM compatible 486/33 microcomputer.
4. Database software: dBase IV v1.5
5. Text Editor: Word Perfect 5.1

2.2 **Reagents**

2.3 **Forms**
Field data form figure 2.3

3.0 **Calibration Standards**

4.0 **Procedures**

4.2 **Start-up**

4.2.1 Placement of Litter Collectors
The outside edge of each collector was located 1.0 to 1.2 m from the tree base; situated in a position around the tree so only ponderosa pine foliage was above it. Thirty collectors were located in each of the three plots, four of these collectors were located on cardinal compass directions around a single tree. The collectors were installed during the final two weeks of April, 1992.

4.2.2 Data Processing
dBase must be installed and running correctly. A dBase file

named LITTER92.DBF with the structure listed in figure 4.2 must be in a subdirectory that dBase can be run from. A text editor capable of outputting in ASCII format must be available for entry of the field data.

4.3 **Routine Operation**

Every 30 days ponderosa pine needles in the Needle Collectors will be counted. Other needles and debris will be discarded. The count will be written on the field data form. If the collector has been damaged and an unknown number of needles lost, a note should be put next to the collector number and the validation code will be set to N. Every 60 days (or alternate 30 day visits) needles will be bagged for counting, drying and weighing in the lab. The needles from each collector will be put in a separate bag, labeled with the collector ID. The bags will be dried for 48 hours at 70 deg C in a drying oven. The paper bags will be stored in plastic trash bags after they have been dried. The needles in the bags will be counted and weighed and the data will be recorded on the field data sheet. The field data sheet will be typed into an ASCII document with the format as in figure 4.3. Data entry person will check typed data against original field sheet, correct any errors and give an electronic and paper copy of the file to the data manager. The data manager will check the format of the file and append the data to the database file LITTER92.DBF, filing a hard copy of the data with the original field data sheets. Duplicate copies of electronic files will be kept on floppies.

5.0 **Quantification**

6.0 **Quality Control**

7.0 **References**

Figure 4.2 Database Structure for Needle Litter Data

Field	Field Name	Type	Width	
1	JDATE	Numeric	3	Julian date data collected
2	FIELD_ID	Character	4	Label on Litter Collector
3	CNTVAL	Logical	1	Validation flag
4	COUNT	Numeric	3	Count of number of ponderosa pine needles
5	WEIGHT	Numeric	6.3	Weight of needles
6	DAYS	Numeric	3	# days since last visit

Figure 4.3 Format for Data Entry
Col. 1: Julian date data was collected
Col. 2: Field Id labeled on collector
Col. 3: Validation code (Y=valid, N=collector disturbed or damaged)
Col. 4: Needle count (-99 for missing data)
Col. 5: Needle weight (if not weighed = 0, -99 = missing)
Col. 6: # of days since last visit

148	2	Y	13	0	36
148	7	Y	9	0	36
148	11	Y	17	0	36
148	15	Y	14	0	36
148	16	Y	10	0	36
148	18	Y	46	0	36
148	22	Y	20	0	36
148	30	Y	4	0	36
148	47	Y	9	0	36
148	52	Y	10	0	36
148	67	Y	19	0	36
148	69	Y	12	0	40
148	72	Y	10	0	40
148	73	Y	8	0	36
148	76	Y	8	0	36
148	77	Y	7	0	40
148	92N	Y	10	0	40
148	92S	Y	4	0	40

LITTER COLLECTOR LOCATIONS

PLOT 1 Placed on 4-21-94 except * placed on 4-17-92

Tree No.	Location	Tree No.	Location	Tree No.	Location
2	1 UP 11 R	67	43 UP 16 R	98 *	91 UP 21 L
7	1 UP 8 L	69 *	48 UP 16 R	114 *	90 UP 1 L
11	5 UP 7 R	72 *	53 UP 3 L	116 *	91 UP 5 L
15	8 UP 10 R	73	57 UP 5 L	169	7 UP 26 R
16	8 UP 4 R	76	56 UP 20 L	170	29 UP 34 L
18	8 UP 0 R	77 *	63 UP 6 L	172	50 UP 33 R
22	8 UP 20 R	92 N *	81 UP 21 L	173	56 UP 29 R
30	11 UP 19 L	92 S *		175	65 UP 25 R
47	30 UP 7 R	92 E *		177	51 UP 30 L
52	31 UP 21 L	92 W *		178 *	88 UP 27 L

PLOT 2 All placed on 4-24-92

Tree No.	Location	Tree No.	Location	Tree No.	Location
204	4 UP 1 L	253	12 UP 18 L	342	47 UP 20 R
217	8 UP 6 L	263	16 UP 10 L	366	68 UP 3 L
218	0 UP 0 R	270	19 UP 3 L	368	69 UP 0 R
221	3 UP 15 R	278	21 UP 5 R?	373	83 UP 11 R
225	9 UP 12 R	285 N	30 UP 10 R	375	80 UP 14 R
228	8 UP 5 R	285 S		379	81 UP 18 L
234	12 UP 10 R	285 E		383	84 UP 9 L
241	16 UP 20 R	285 W		408	109 UP 8 R
242	16 UP 5 R	289	36 UP 1 R	414	115 UP 4 R
248	9 UP 1 L	291	25 UP 6 L	416	116 UP 11 R

PLOT 3 All placed on 5-01-92

Tree No.	Location	Tree No.	Location	Tree No.	Location
513 N	5 UP 16 L	549	27 UP 16 L	613	97 UP 19 L
513 S		550	29 UP 18 L	614	84 UP 23 L
513 E		564	47 UP 24 R	618	111 UP 9 L
513 W		566	48 UP 16 R	620	105 UP 3 R
514	4 UP 20 L	586	61 UP 13 R	621	120 UP 5 L
516	15 UP 14 R	587	60 UP 24 R	622	128 UP 11 L
526	26 UP 17 R	601	80 UP 10 R	623	128 UP 2 R
530	27 UP 6 R	603	84 UP 13 R	624	135 UP 5 R
540	18 UP 7 L	605	87 UP 19 R	626	122 UP 18 L
545	23 UP 20 L	612	89 UP 0 R	627	129 UP 3 L

LITTER COLLECTOR LOCATIONS

PLOT 1 All cleaned out or placed on May 13, 1993

Tree No.	Location	Tree No.	Location	Tree No.	Location
Pines					
2	1 UP 11 R	67	43 UP 16 R	98	91 UP 21 L
7	1 UP 8 L	69	48 UP 16 R	114	90 UP 1 L
11	5 UP 7 R	72	53 UP 3 L	116	91 UP 5 L
15	8 UP 10 R	73	57 UP 5 L	169	7 UP 26 R
16	8 UP 4 R	76	56 UP 20 L	170	29 UP 34 L
18	8 UP 0 R	77	63 UP 6 L	172	50 UP 33 R
22	8 UP 20 R	92 N	81 UP 21 L	173	56 UP 29 R
30	11 UP 19 L	92 S		175	65 UP 25 R
47	30 UP 7 R	92 E		177	51 UP 30 L
52	31 UP 21 L	92 W		178	88 UP 27 L
Firs					
8	1 UP 4 L	27	13 UP 20 R	53	33 UP 16 L
80	65 UP 11 R	113	89 UP 1 L		
Oaks					
1	0 UP 17 R	36	16 UP 16 L	46	24 UP 14 R
48	36 UP 8 R	86	74 UP 14 R		

PLOT 2 All cleaned out or placed on May 18, 1993

Tree No.	Location	Tree No.	Location	Tree No.	Location
Pines					
204	4 UP 1 L	253	12 UP 18 L	342	47 UP 20 R
217	8 UP 6 L	263	16 UP 10 L	366	68 UP 3 L
218	0 UP 0 R	270	19 UP 3 L	368	69 UP 0 R
221	3 UP 15 R	278	21 UP 5 R?	373	83 UP 11 R
225	9 UP 12 R	285 N	30 UP 10 R	375	80 UP 14 R
228	8 UP 5 R	285 S		379	81 UP 18 L
234	12 UP 10 R	285 E		383	84 UP 9 L
241	16 UP 20 R	285 W		408	109 UP 8 R
242	16 UP 5 R	289	36 UP 1 R	414	115 UP 4 R
248	9 UP 1 L	291	25 UP 6 L	416	116 UP 11 R
Firs					
261	16 UP 5 L	336	38 UP 5 R	387	84 UP 18 L
423	117 UP 5 L	325	40 UP 15 L		
Oaks					
206	5 UP 11 L	235	12 UP 19 R	339	38 UP 8 R
353	55 UP 4 R	399	91 UP 9 R		

PLOT 3 All cleaned out on June 3, 1993

Tree No.	Location	Tree No.	Location	Tree No.	Location
513 N	5 UP 16 L	549	27 UP 16 L	613	97 UP 19 L
513 S		550	29 UP 18 L	614	84 UP 23 L
513 E		564	47 UP 24 R	618	111 UP 9 L
513 W		566	48 UP 16 R	620	105 UP 3 R
514	4 UP 20 L	586	61 UP 13 R	621	120 UP 5 L
516	15 UP 14 R	587	60 UP 24 R	622	128 UP 11 L
526	26 UP 17 R	601	80 UP 10 R	623	128 UP 2 R
530	27 UP 6 R	603	84 UP 13 R	624	135 UP 5 R
540	18 UP 7 L	605	87 UP 19 R	626	122 UP 18 L
545	23 UP 20 L	612	89 UP 0 R	627	129 UP 3 L

1.0 **General Discussion**

The litter samples of ponderosa pines, white firs, and black oaks were collected from plots 1, 2 and 3 of the Barton Flats study area, and weighed, as outlined in RFL 22. The samples were analyzed for concentrations of carbon, nitrogen, sulfur, calcium, magnesium, sodium, potassium, and phosphorus.

1.1 **Purpose of Procedure**

The purpose of the procedure was to compare the elemental concentrations of trees both within and between plots, within and between species, and between collections occurring in different years.

1.8 **Related Procedure List**

Standard Operating Procedures:

RFL 21	Placement of Litter Collectors
RFL 22	Needle and Leaf Litter Collection and Weighing
LM 2.13	Elemental Combustion Analysis: Plant Tissue
LM 2.9	Multi-Element Analysis: Perchloric Digest
LM 6.5B	Measurement of Perchloric Phosphorus - TRAACS 800
LM 6.9	Atomic Absorption - Perkin Elmer 5000

4.0 **Analytical Procedures**

4.1 **Grinding**

The tissue samples were placed in a 70° C oven for at least 24 hours prior to grinding. The samples were ground to pass a 20 mesh sieve as outlined in LM SOP 2.1.

4.2 **Perchloric Digest**

Before analyzing for calcium, magnesium, sodium, potassium or phosphorus, the samples were digested in a nitric/perchloric acid mixture as outlined in LM SOP 2.9.

4.2.1 Calcium, Magnesium, Sodium, Potassium Determinations

The concentrations of calcium, magnesium, sodium, and potassium were determined using atomic absorption spectrophotometry as outlined in LM SOP 6.9.

4.2.2 Phosphorus Determinations

The concentrations of phosphorus were determined using automated colorimetry as outlined in LM SOP 6.5B.

4.3 **Carbon, Nitrogen and Sulfur Determinations**

The concentrations of carbon, nitrogen, and sulfur were determined using combustion gas chromatography as outlined in LM SOP 2.13.

7.0 **References**

Laboratory Methods and Training Manual. Forest Fire Laboratory. USDA Forest Service.

1.0 **General Discussion**

The methods describe the establishment and evaluation of plots including ponderosa and/or Jeffrey pines. These plots are intended as long-term trend plots to correlate ozone exposures with biological response of sensitive trees.

1.1 **Purpose of Procedure**

The purpose is to provide sufficient information to locate, mark and describe a forest monitoring plot that provides a suitable population of ponderosa and/or Jeffrey pines needed to monitor the long-term effects of ozone exposure.

1.2 **Measurement Principle**

Potential plot locations are selected using stratified random sampling and simple surveying principles are involved in establishing plots, namely, measurement of compass bearing decribing the orientation of the long dimension of the rectangular plot, measurement of ground distances with corrections for slope, and measurement of tree diameters at breast height.

1.3 **Measurement Interferences and their Minimization**

Interferences relate mainly to the skill of the field crew in making the required measurements. Compass readings could be influenced if the compass was not held in a level position, and the line of sight is not free from obstruction so that the compass transect has to be broken into several short segments. Ground distance and tree diameter measurements are most influenced by the lack of adequate tautness of the metal or cloth measuring tapes used. Slope corrections for distance are generally not important because plot center lines are normally placed parallel to contour lines. Proper training of field crews is the most useful way of minimizing interferences.

1.4 **Ranges and Typical Values of Measurements Obtained by the Procedure**

See Section 4.1

1.5 **Typical Quantifiable Limits, Precision, and Accuracy**

Compass readings with a handheld compass are expected to be accurate within $\pm$ 5 degrees. Distance measurements with a cloth or metal tape are $\pm$ 0.1 m and diameter tape measurements $\pm$ 0.1 cm. Altimeter measurements are expected to be accurate within $\pm$ 10 m. See Section 6.1 for additional variables and criteria.

1.6 **Responsibilities and Personnel**

Paul Miller, David Jones and Susan Schilling are responsible for this procedure.

1.7 **Definitions**

Explained in Section 4.1

1.8 **Related Procedures**

Standard Operating Procedures:

RFL 25 Initial Determination of Tree Characteristics and

Repeated Measurement of Branch and Whorl Variables

2.0 Apparatus, Instrumentation, Reagents, Forms

2.1 Apparatus and Instrumentation

1. USGS topography maps
2. vegetation maps or color aerial photographs
3. altimeter
4. forester's compass
5. 50 m cloth or metal tape
6. diameter tape for measuring bole or stem diameters of trees

The use of Geographical Positioning Systems (GPS) to determine latitute and longitude of the plot reference tree or rock is desireable but equipment is not generally accessible.

2.2 Reagents

Not applicable

2.3 Forms

2.3.1 Data Entry

Field data entry for most variables may be on data sheets (**Figures 1,2**) or in a field data recorder (FDR)(Corvallis MC-V with Mbase) using programs available from the data archiving group. Tree and Whorl data recorded on data sheets (**Figure 2**) can be entered electronically on a PC computer using software available from data archiving group at the Riverside Fire Laboratory. Factors to consider before choosing to use the FDR include:

- availability of a PC with dBase (or similar software that can import dBase format file) for daily download of collected data.
- availability of computer support people to help with downloading.
- how comfortable you are using the MC-V and computers in general.
- is the MC-V in good condition? (is the internal battery OK?).

Included as Appendix 2 and 3 are the manuals for the data input software for the FDR and the data entry software for the PC.

3.0 Calibration Standards

Only the altimeter is in need of daily calibration. The device is adjusted at a USGS monument if available or at roadside signs marking elevation.

4.0 Procedures

4.1 General Flow Diagram

Randomly select potential plot locations on a topography map > visit potential sites until 3 are determined to have the required site and forest community composition > record site characteristics at plots > prepare sketch map of plot location > label plot > select and mark trees.

4.1.1 Site selection for plots

Sites for long or short-term monitoring plots are selected randomly from predetermined population stratifications (**Figure 3**). These plots must be located within a specified radius of a continuous pollutant monitoring instrument. Population stratifications include species, geographical or land-use units (e.g., National Forests, Parks, mountain ranges), and landscape characteristics such as river drainages. The degree of stratification should increase with decreasing resources for plot establishment (monetary or personnel constraints), i.e., the fewer the number of plots that are affordable, the more highly stratified the sample population should be to reduce inherent and environmental variability between and within plots. The selected plots should be established within 5 kilometers (3.1 miles) distance and within + 150 meters (492 feet) elevation of the instrument monitoring station. Steep slopes (> 60%) should be avoided for safety.

Within the defined population to be sampled, randomly select three or more potential plot locations (using topographical maps, vegetation maps, or Geographical Information Systems-GIS) around the continuous or passive ozone monitor (consult EPA for specifications). Population stratification should restrict potential plots to within major landform boundaries (**Figure 4**) and within major slope positions (**Figure 5**). In effect this eliminates potential sample points that are within 200 meters of two landform types or slope positions. The purpose is to eliminate an increase in tree-to-tree variability that occurs when trees are exposed to a heterogeneous suite of environmental influences that are often found in different landform types. In practice it prevents the plots from overlapping landform types (**Figure 4**) or slope positions. Plot acceptance and rejection criteria (e.g., stand density, pest infection levels), and plot substitution criteria (e.g., nearest acceptable plot within 0.5 km of random sample point), should be determined before locating plot sample points in the field. In general avoid stands of trees that are obviously stressed due to insects, disease, chemicals (except ozone), nutrients, or other factors. Institute a plot substitution criteria that considers the general topography of the land with respect to landform types and slope position. The substituted stand should be within 0.5 kilometers of the original sample point. Record sample point locations on land navigation systems (Loran or Geographical Positioning Systems-GPS) or topographical maps.

Plot selection factors:

- Landform type: The entire extent of the plot should be within the same general landform type (**Figure 4**). Transects (direction of long dimension of the plot) should run generally along the contour, and in a straight line for mapping convenience. Allow 200 m for plot length. This effectively eliminates severely dissected landform types less than 200 m in size.

• Forest type: Dominant trees should be ponderosa or Jeffrey pine. At least 30 trees should be as tall as the general forest canopy. Stand density should be great enough to allow 50 trees to be selected within the 200 m length of the plot.

• Pests and pathogens: Severe needle cast fungus infections, e. g. Elytroderma deformans, or dwarf mistletoe infections should be avoided. Large beetle killed groups of trees should be avoided as beetles may spread to nearby living trees the following year. Group kills are also an indicator that soil moisture holding capacity is low thus making nearby trees susceptible to bark beetle attack during subsequent drought years.

• Microenvironments: Trees growing in odd micro-environments (bare rock, serpentine soils, etc) should be avoided unless there is a specific purpose to study how these variables may influence response to ozone exposure.

Establishment of plots:

After locating a stand of trees that meet the site selection criteria, establish the plot (**Figure 6**):

• Take an azimuth parallel to the general contour of the slope (i.e., if terrain is sloping) generally follow the contour of the slope. On flat areas with little or no slope, take a random azimuth direction.

• Establish an initial 200 meter center transect line along this azimuth.

• Identify a plot locator tree (species, dbh, characteristics) and measure and record the distance and azimuth from the plot locator tree to the beginning of the transect line. Plot locator trees are prominent trees in the immediate area of the plot that may aid in relocation of the plot and plot trees.

• Tree selection

  - Survey all the open-grown, dominant, codominant, intermediate, and over-topped trees, > 10 cm dbh (**Figure 7**) of the selected species within 40 meters on each side of the center line (total width of transect = 80 meters).

Table 1. Tree Selection Tally Sheet

Tally of Number of Trees Within the Plot *

DBH inch	cm	Open	Crown Class Dom.	Codom.	Int.	Sup.
4	10					
6	15					
8	20					
10	25					
12	30					
14	35					
16	40					
18	45					
20	50					
22	55					
24	60					
26	65					
28	70					
30	75					
32	80					
34	85					
36	90					
38	95					
40	100					
42	105					
44	110					
46	115					
48	120					
50	125					
50+	(Specify)					

Totals:

Sum Canopy Subcanopy

* Note unpruneable trees with asterisk.

- Count all trees equal to or greater than 10 cm dbh and classify crown position (use D tape, caliper or make estimate of dbh). Use a Tree Selection Tally Sheet (**Table 1**). Exclude from the group of numbered trees the unpruneable trees or trees that have severe mechanical wounds, root disease, excessive lean, bark beetles, needle diseases, dwarf mistletoe, etc.

- Randomly select the first 50 or at least 30 dominant or codominant trees with pruneable mid-to-lower crowns (10-30 feet high). Choose remaining subdominant trees systematically, for example, pick every other, every third, or pick two skip one, working from the beginning to the end of the transect.

Example #1: 1 hectare transect with 150 pines > 10 cm dbh

Crown class:	Open	Dom.	Codom.	Intermed.	Suppress.
Numbers:	5	20	30	40	55
Totals:		55		95	

Ratio of canopy trees to total= 55/150

Candidates: Canopy
52 pruneable — Randomly pick 30

Subcanopy
80 pruneable — Systematically pick every 4th tree (20)

Final sample= 50 trees.

Example #2: 1/2 hectare transect with 75 pines > 10 cm dbh.

Crown class:	Open	Dom.	Codom.	Intermed.	Suppress.
Numbers	20	20	20	10	5
Totals:		60		15	

Ratio of canopy trees to total= 60/75

Candidates: Canopy
55 pruneable — Randomly pick 40

Subcanopy
15 pruneable — Systematically pick two, skip one (10)

Final sample= 50 trees.

- Do not choose trees where only the very lowest branches of the lower crown can be reached (the very lowest branches may not accurately reflect the rest of the lower crown and will die as the tree ages). Choose trees where the pole-pruner can reach at least the middle of the lower crown. Continue to select trees (flag initially if you have doubts about finding a sufficient number of trees in any one landform area) until at least 30 dominant/codominant and 20 intermediate or overtopped trees have been located (keep the number of overtopped trees to $\leq$ 10).

• Extend the 200-meter transect line if 50 trees meeting the above tree selection criteria are not found in the initial 200 meters, continue the center transect line along general direction of the contour of the slope, and along the same azimuth, until 50 acceptable trees are found.

• Trees that die after plot establishment will not be replaced. If the total number of live trees drops below 20 the plot may be replaced. The procedure for plot replacement begins with an attempt to locate a suitable plot location in the near vicinity of the original plot. If that is not possible then potential plot locations are located on the same map or photograph originally used to locate the first plot. Plot sites are visited on ground and investigated to see if they fulfill the necessary acceptance criteria used originally.

• Trees should be tagged on the side facing the center line with a numbered aluminum tag affixed with an aluminum or galvanized nail (#7 siding nail) at or near dbh (1.37m above the ground) (**Figure 8**). The diameter at breast height (dbh) should be taken immediately above the nail so that subsequent remeasurements can always be done at the same point.

• Calculate the site index for each plot by selecting 3 dominant or codominant trees. Trees should spatially represent the plot and not have any obvious stress from competition. These trees are measured for height and cored for a count of the number of radial rings. These measurements are then evaluated by the use of a site-index table, see Appendix 1.

• Sketch the relative location of each tree on a site data sheet (**Figure 1**) or on graph paper and attach to site data sheet.

• Photocopy a USGS 7 1/2 minute series quadrangle topographical map and sketch in the plot locations. Show any prominent site features (old burn area, rock outcrops). Attach to site data sheet. Determine the latitude, longitude and elevation from the topo map.

• Write a description of how to find the plots (approach logs) (**Figure 9**) and attach to site data sheet. Include photographs (if possible) of the site, particularly from a point distant to the site, where plot trees can be seen. Record as much information about the site as possible to aid in relocation of the site. Remember that someone totally unfamiliar with the area may be the one to relocate the site 3, 5, or 10 years later. A plot that cannot be relocated is a wasted effort for the person(s) establishing the plot and for the land managers relying on the information.

Site and stand-level data:

After locating, tagging, and mapping 50 acceptable trees, record the following management data on a site data sheet (**Figure 1**):

• management unit/site (e.g., El Dorado NF, Yosemite NP, etc.)
• names of crew members
• date of data collection
• plot number/designation
• topo map
• azimuth
• landform type
• latitude
• longitude
• elevation
• site index
• description of plot locator tree

Also record the following site level variables:

• slope position (**Figure 5**)
• percent slope (Zedaker, 1990)
• aspect (Zedaker, 1990)
• microrelief (planar, convex, concave) (**Figure 10**, Zedaker, 1990)
• forest type/community (record the 3 main tree species)
• land use (natural or ?)
• understory vegetation (grass, shrub species...)

4.2 **Start-up**

Not Applicable

4.3 **Routine Operations**

The accomplishment of plot location and establishment can be done anytime of the year as long as there is road access and snow depth does not present a difficulty. Generally the work would be done in June-July in preparation for evaluation of tree condition (See RFL 25) in August-September.

4.4 **Shutdown**

Not Applicable

5.0 **Quantification**

Not Applicable

6.0 **Quality Control**

6.1 **Site data**

Objectives: It is proposed that site data variables will be obtained by 2 independent observers, at least a crew of 2. If there is disagreement a third observation will be obtained. Measured variables should be within 10%.

- topo map (location)
- azimuth
- latitude
- longitude
- elevation
- site index
- landform type
- slope position
- percent slope
- microrelief
- aspect
- forest type/community- 3 main tree species
- land use
- understory vegetation
- description of plot locator tree

To insure that data collection meets the acceptable data quality objectives, the project cooperators will perform or delegate the remeasurement of plot variables on one-third of the plots (1 of 3 plots) established around each ozone monitor. The % frequency of misclassification or > 10% difference in measured variables will be recorded. An independent remeasurement by the QA crew will also be done.

7.0 **References**

Zedaker, S. and N. S. Nicholas. (1990) Quality assurance methods manual for site classification and field measurement. U.S. EPA, EPA/600/3-90/082. 45pp.

Figure 1. Site data sheet.

MANAGEMENT UNIT/SITE:______________________PLOT NAME/NUMBER:__________CREW:____________________

TOPO MAP:__________________________LANDUSE:____________________________DATE:_________________________

PLOT LOCATOR TREE (SPECIES, DBH, CHARACTERISTICS):____

ELEVATION:________________LATITUDE:______________________LONGITUDE:___________________________________

COMPASS BEARING AT STARTING POINT:________________%SLOPE:_____________ASPECT:_______________________

FOREST TYPE/COMMUNITY (3 MAIN TREE SPECIES):______________________SITE INDEX_____________________________

UNDERSTORY VEGETATION:__________________________

SLOPE POSITION: summit shoulder backslope footslope terrace bottom

LANDFORM: ridgetop spur-ridge noseslope headslope sideslope cove draw

SKETCH IN LOCATION OF EACH TREE (WITH TREE NUMBER), AS ACCURATELY AS POSSIBLE.

SKETCH IN SECTION OF ROAD, TRAIL, OR PROMINENT GEOGRAPHIC FEATURE TO FACILITATE RELOCATING PLOT IN FUTURE.

ATTACH APPROACH LOGS AND PHOTOS OF PLOTS IF AVAILABLE

Figure 2. Tree and whorl data sheet.

FOREST:	SITE:	PLOT:	TAG:
CREW:	COMMUNITY:		
	ASPECT:	SLOPE:	ELEVATION:
DATE:	LANDFORM:	SLOPE POSITION:	

SP	#	FOL LEN	WHORL #	CM	FR	NL	BIOTIC	ABIOTIC	COMMENT
			1						
AGE			2						
			3						
SNDX	1		4						
			5						
			6						
POS			7						
			8						
HT			1						
			2						
			3						
DBH	2		4						
			5						
MREL			6						
			7						
			8						
ROCK			1						
			2						
MIST			3						
	3		4						
			5						
CONK			6						
			7						
BEET			8						
			1						
			2						
FIRE			3						
	4		4						
MECH			5						
			6						
			7						
LIGT			8						
			1						
BROM			2						
			3						
	5		4						
%LC			5						
			6						
LCR			7						
			8						

UNITS USED:
DBH ________
HT ________
FOL LEN ________
NL ________

FR = FAS RET (WHOLE WHORL)
0 = NONE
1 = 1 - 33%
2 = 34 - 66%
3 = 67 - 100%

CHL. MOTTLE
0 = NONE
1 = 1 - 6%
2 = 7 - 25%
3 = 26 - 50%
4 = 51 - 75%
5 = 76 - 100%

ABIOTIC INJURY
0 = NONE
1 = < 25%
2 = > 25%

BIOTIC INJURY
0 = NONE
1 = < 25%
2 = > 25%

MREL
PL = PLANAR
CC = CONCAVE
CX = CONVEX

BOLE INJ
0 = ABSENT
1 = PRESENT
2 = SEVERE

MIST: 0 - 6

%LC = % LIVE CROWN

LCR = LIVE CROWN RATIO (FILL-IN)

ROCK = % ROCK IN 20X TREE DIA AREA

SNDX = SITE INDEX

Figure 3. Stratified random sampling design with grid squares approximately 3.2 kilometers. Within each grid square that contains the target population to be sampled a random sample point is chosen.

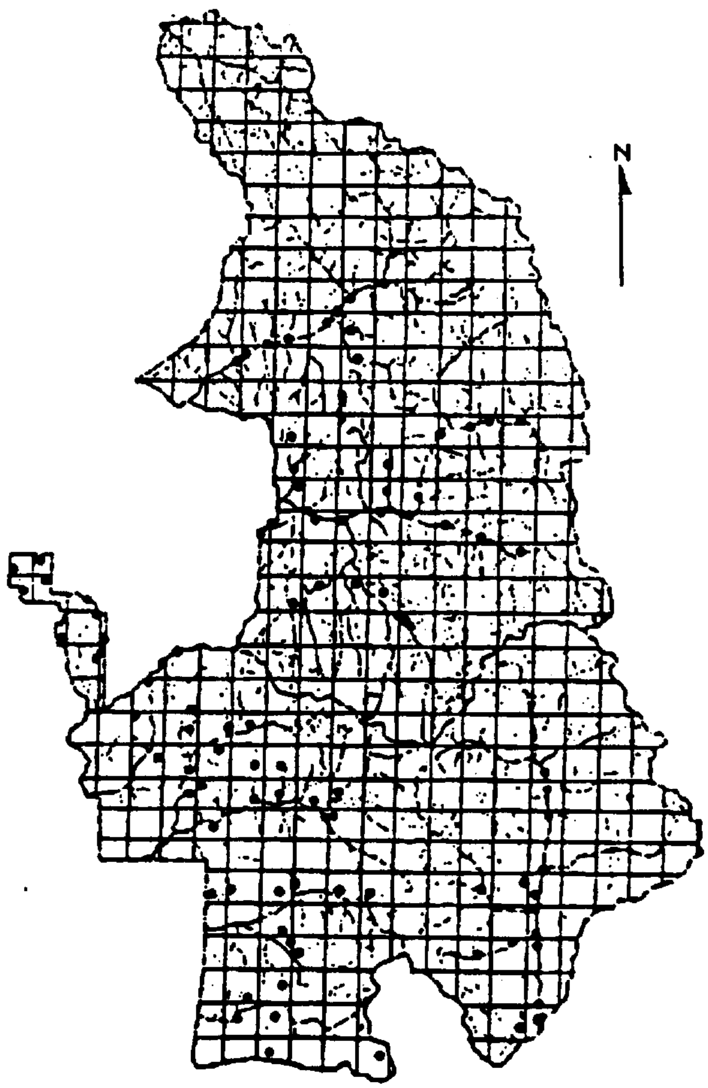


Figure 4. Seven types of Landforms: Ridgetop, Spur-Ridge, Noseslope, Headslope, Sideslope, Cove, and Draw.

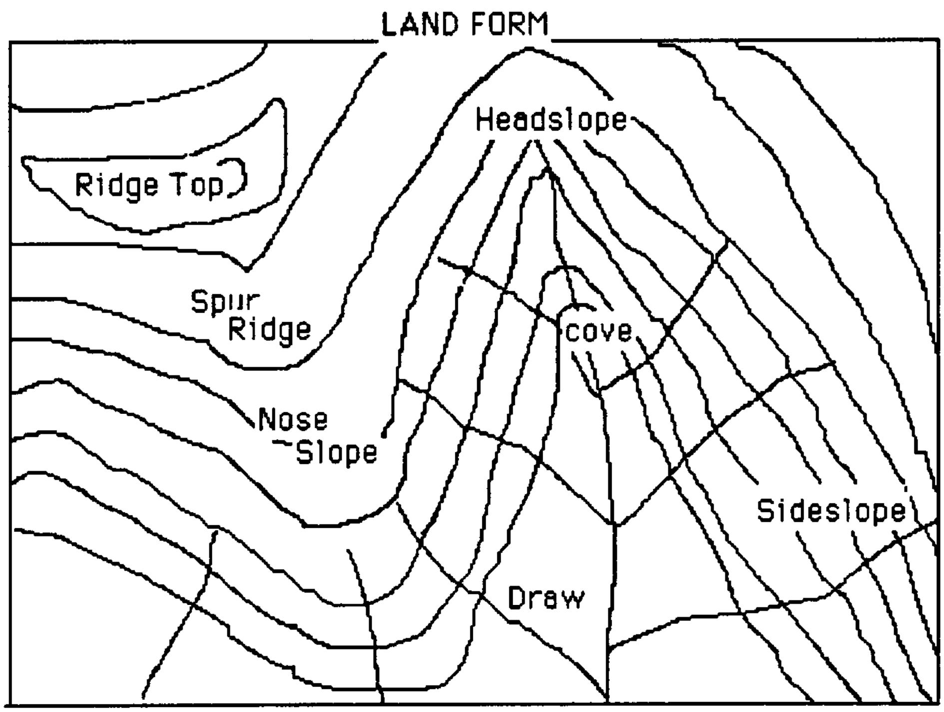


Figure 5. Slope positions that are available for establishment of WPM plots. Six slope positions: Summit, Shoulder, Backslope, Footslope, Terrace, and Bottom (Floodplain). Plots should fall within any slope position without overlap between slope positions.

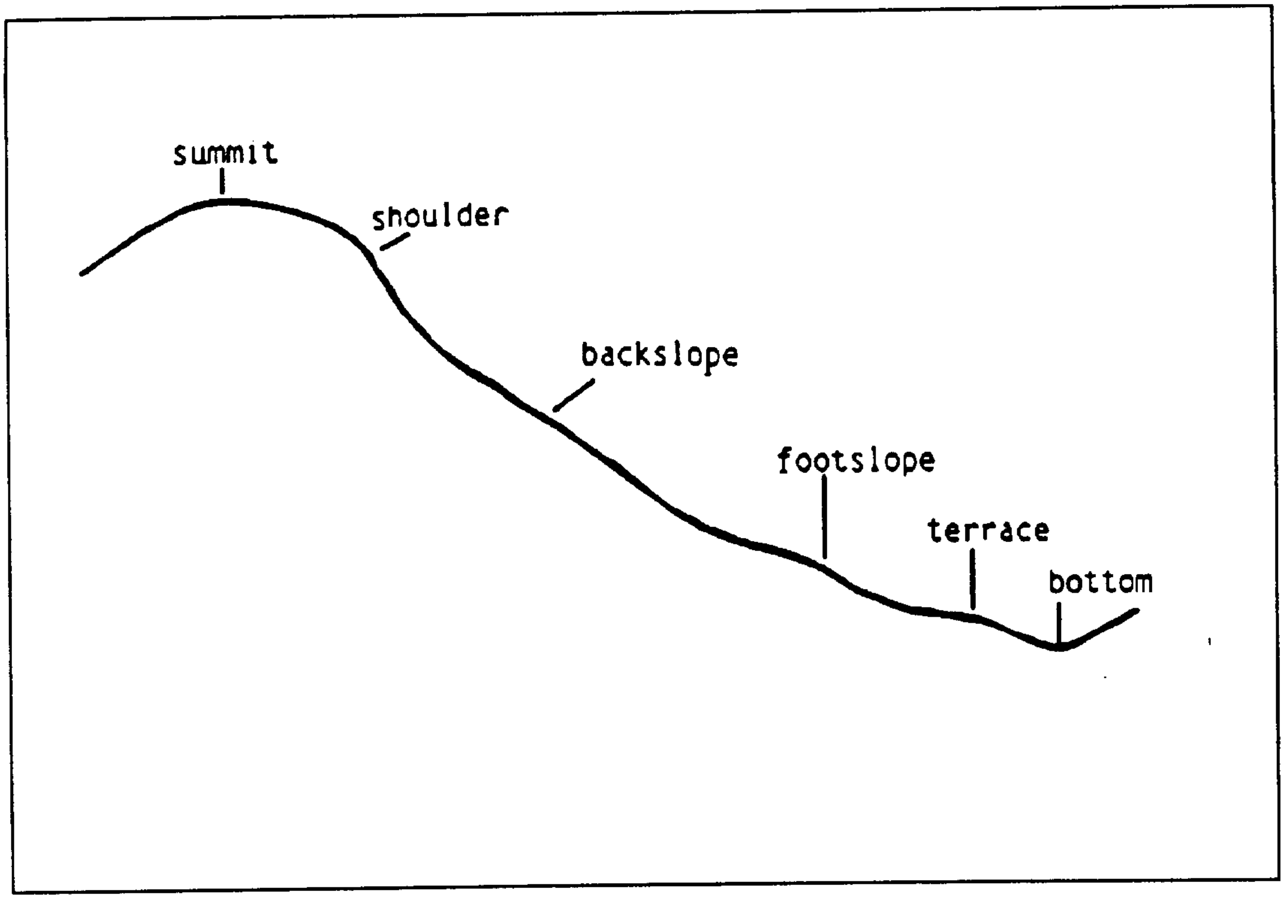


Figure 6. Establishment of a plot containing 50 trees. (a) Plots are 40 meters wide (20 meters on each side of the transect line). Length of transect line in indeterminate; it is extended until 50 trees meeting specifications are found. (b) Mapping 50 trees within the plot bounds and relevant to plot outline. (c) Mapping 50 trees in the plot; 46 are within the plot perimeter, with 4 trees mapped outside the plot perimeter.

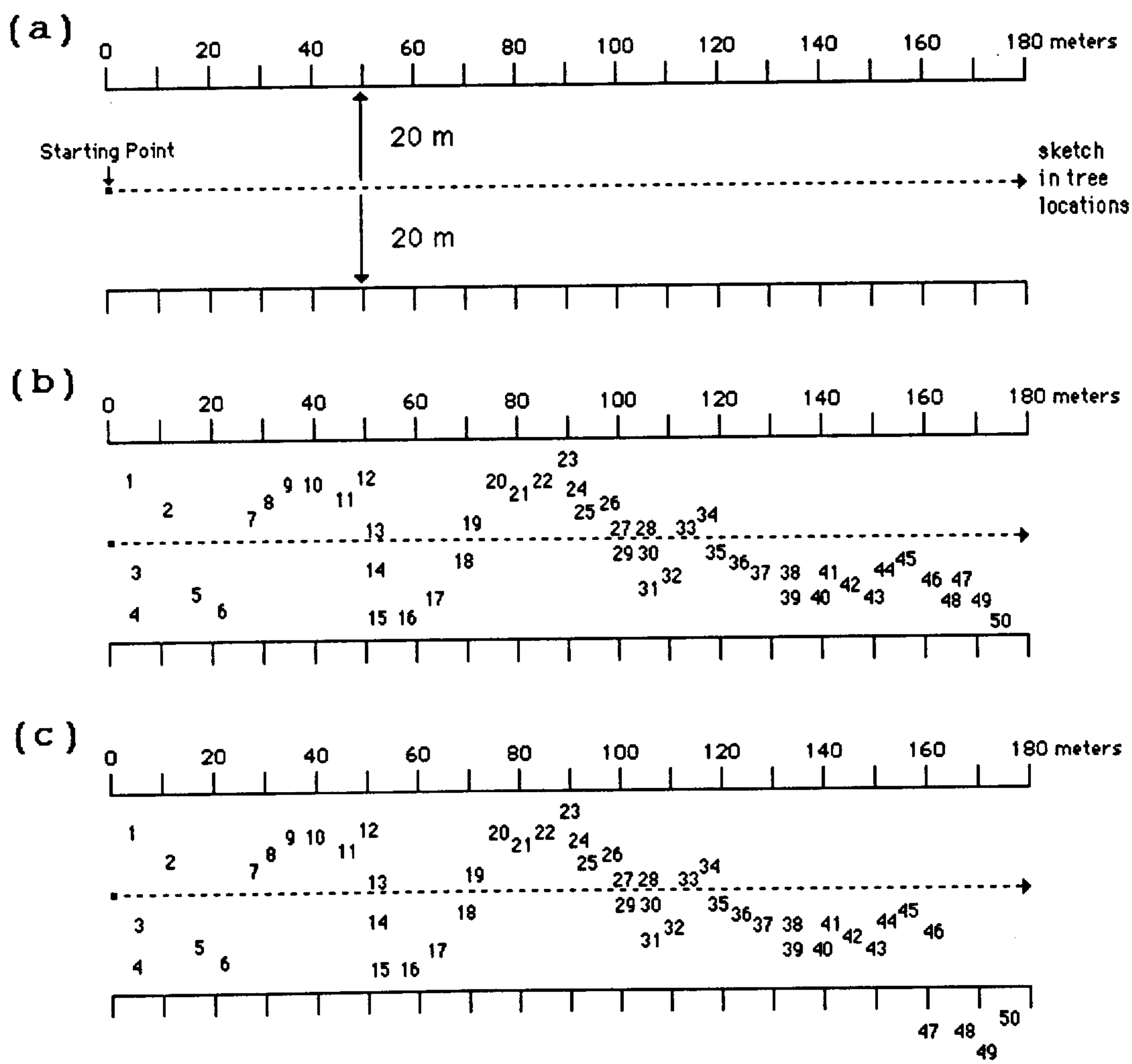


Figure 7. Crown Position Classes: D = Dominant, C = Codominant, I = Intermediate, S = Suppressed, OG = Open Grown.

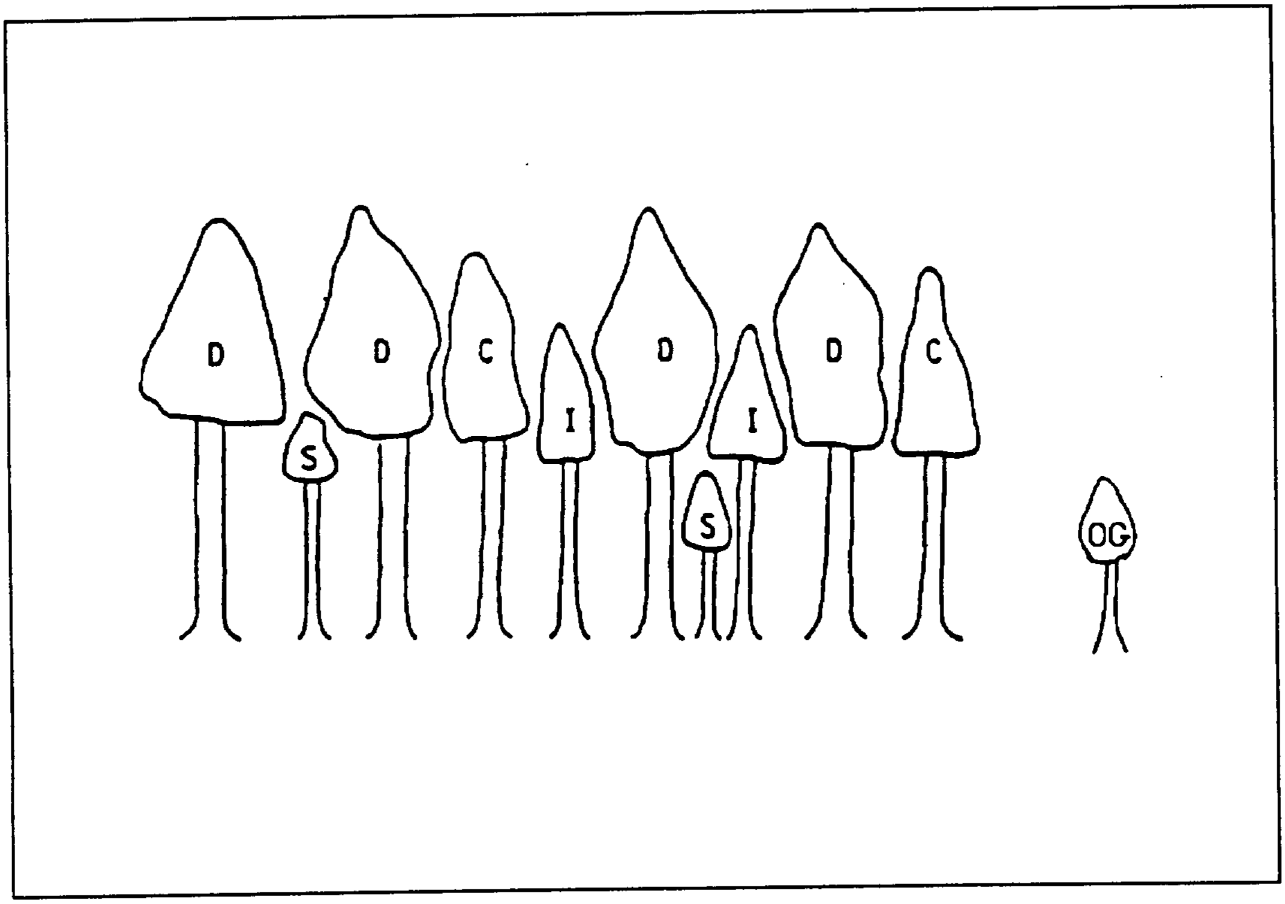
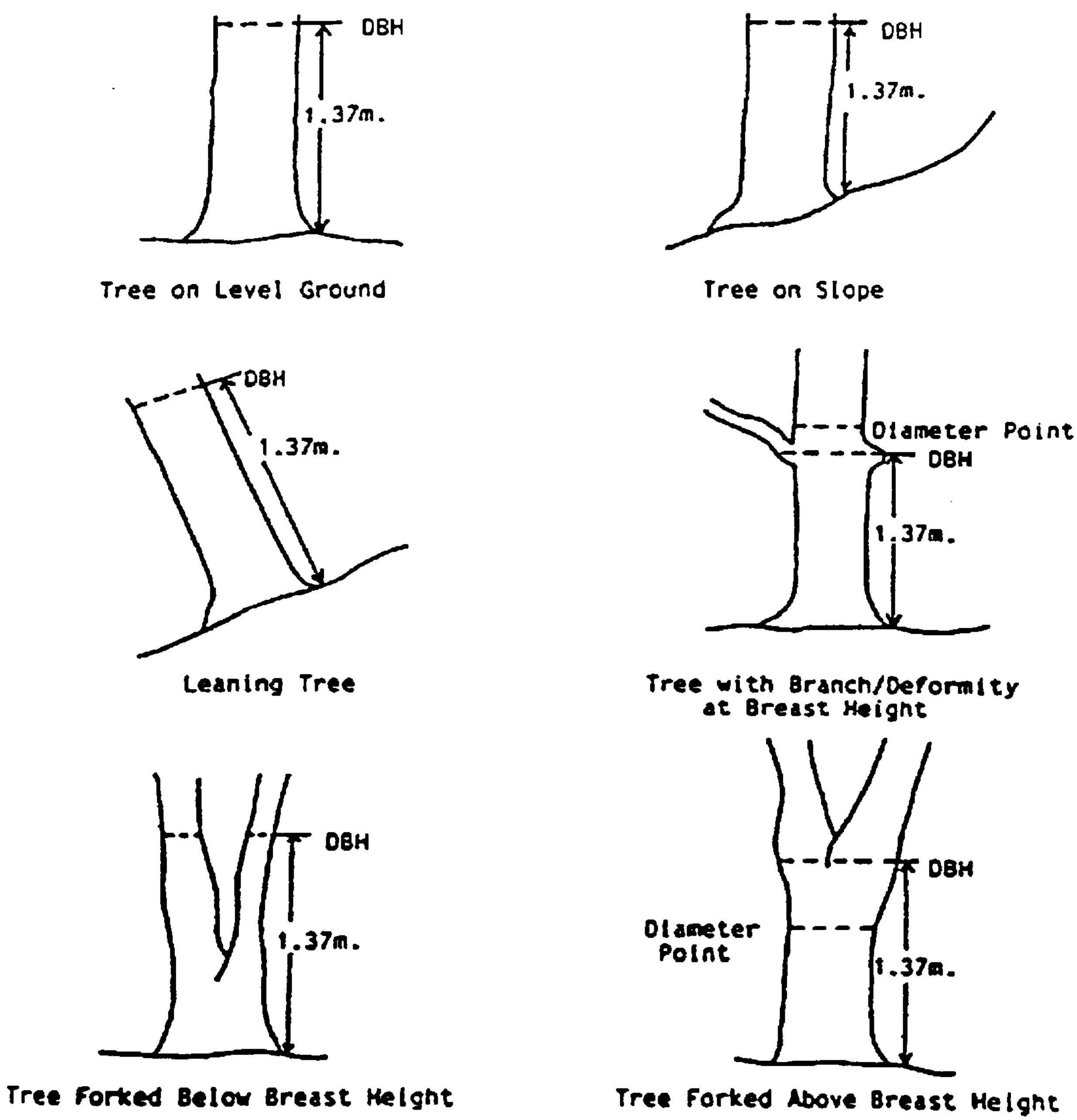


Figure 8. Proper method for measurement of diameter at breast height (dbh) of the tree bole.



Tree on Level Ground

Tree on Slope

Leaning Tree

Tree with Branch/Deformity at Breast Height

Tree Forked Below Breast Height

Tree Forked Above Breast Height

Figure 9. Example of an approach log.

Lassen Volcanic National Park
Directions to yellow pine ozone injury plots 1 through 3

PLOT 1

The trail to plot 1 begins in Manzanita Lake housing area, behind cabin 14. From the trail head, travel at approximately 182 deg. south for about 0.5 km, where it intersects with the stream. The Forest Service water tower can be seen about 30 m downstream. The trail to plot 1 continues due south, about 40 m upstream from the tower. If the stream is too full to cross, there is a small footbridge about 0.25 km downstream. Once across the stream, and about 40 m upstream from the tower, head at approximately 192 deg. south for about 350 m, then go left at 115 deg. southeast for approximately 110 m. The first rebar for plot 1 is at the northwest end of an open, grassy area, about 28 deg., 18 m from a park boundary stake.

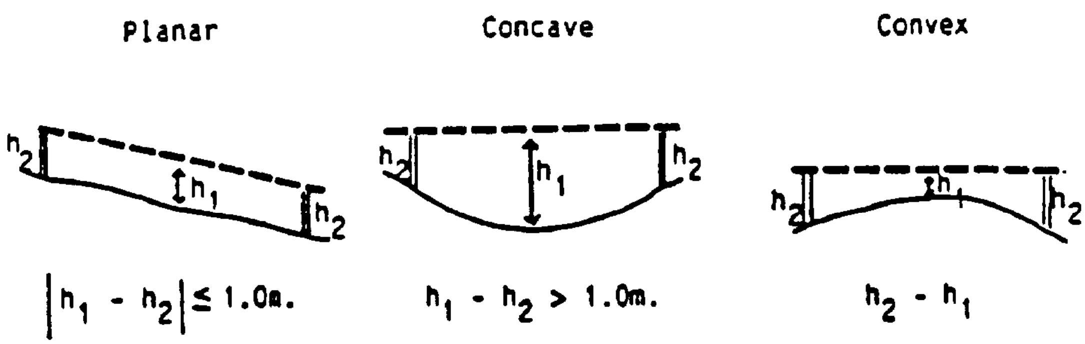
PLOT 2

From the fee booth at Manzanita Lake, take the Manzanita Lake trail around the south side of the lake. After crossing the small footbridge that spans the spillway, proceed down the trail for about 74 m. Then head off the trail to the right, at a heading of about 245 deg. southwest. After about 90 m, you will intersect the plot 2 transect.

PLOT 3

From the first marker at plot 2, head 235 deg. southwest for about 170 m to intersect with plot 3.

Figure 10. Microrelief types to be evaluated under the drip line of each tree. Types are planar, concave, and convex.



Appendix 1-- Site Index

Appendix 2-- Field Data Recorder Operation Instructions

Project FOREST FDR Manual

Do not use these programs unless you have an MC-V in good condition that you are familar with and a PC with the CMT kermit software and database software that can use .DBF (dBase III+) files.

INITIAL LOADING OF PROGRAM AND FILES TO MC-V
There are 10 files on the floppy: 4 program files (.PRG), 3 database files(.DBF), and a backup copy of the 3 empty database files (.BAK).

```
FOREST.PRG
FPLOT.PRG              PLOT.DBF          PLOT.BAK
FTREE.PRG              TREE.DBF          TREE.BAK
FWHORL.PRG             WHORL.DBF         WHORL.BAK
```

Copy all 10 files from the floppy to the PC and put the floppy in a safe place.
Copy all the .dbf and .prg files into the MC-V using Kermit, see page 1-4 to 1-5 in the MBASE manual. Read the manual to see what directory to use on the MC-V.

Example of the commands used to copy the programs and files to the MC-V:
UP-LOAD (from PC to MC-V)

on the PC C:\> MODE COM1:96,N,8,1 <ENTER>

C:\> KERMIT SEND FOREST.PRG **don't enter yet!**

on the MC-V KERMIT R <ENTER>

on the PC <ENTER>
Repeat for all 8 files. The mode command only needs to be entered once.

DAILY DOWNLOAD OF COLLECTED DATA:
The database files (just the .DBF files) on the MC-V should be copied to a PC after each day and printed. Proof-read and note corrections as soon as possible.

Example of the commands used to copy database files from the MC-V to the PC:
DOWN-LOAD (from MC-V to PC)

on the PC C:\mode com1:96,N,8,1 <enter>

on MC-V KERMIT SEND *.DBF **don't enter yet!**

on PC C:\KERMIT R <ENTER>

on MC-V <ENTER>
All dbf files will be copied to the PC. ANY FILES IN THE CURRENT DIRECTORY ON THE PC WITH THE SAME NAMES WILL BE OVERWRITTEN BY THIS. BE CAREFUL TO RENAME THE FILES ON THE PC AFTER THEY ARE DOWNLOADED!

Rename the files on the PC using this system:
AABMMDDX.DBF
AA = abbreviation of the site name
B = T if tree.dbf, W if whorl.dbf, P if plot.dbf.
MM = month, 08 is august
DD = day, this is the day the data was collected
X = 1,2,3,...if there happens to be more than one file for a day

PRINT AND PROOF-READ

On the PC the DBF files can be printed using any software that can use dBase III+ DBF files (dBase III+ and many other database programs can handle dbf files). Print and proof-read the new data after every field day.

As the data is collected and saved on the MC-V, it is appended to the existing dbf file. At some point the files may get too big for the storage area. Another copy of original .dbf files should be copied to the MC-V after the filled dbf files have been saved and checked on a PC.

SENDING IN THE DATA

If you can, make any necessary corrections to the dbf files before you send them. But if you are not familar with dBase just send the files on a floppy and the printouts with the corrections written on them and we can do the corrections.

Send the floppy and printouts to: Dr. Paul Miller
4955 Canyon Crest Drive
Riverside, Ca 92507

STARTING THE INPUT PROGRAM

Change to the sub-directory containing the files you uploaded, and type the command:
MBASE FOREST

See the following pages for explanation of program screens.

GENERAL INPUT INSTRUCTIONS AND CAUTIONS

Make sure KEYBEEP is on (KEYBEEP ON) before the program is started.
To enter data, type the data into the highlighted field and press ENTER.

Data can only be edited while it is on the screen. You cannot go back a screen but you will be given a chance to re-do the data. Once you go to the next screen the data can only be edited on the MC-V by exiting the program and using the commands available in MBASE (EDIT, BROWSE).

If you find another whorl when entering oldest first, enter them in the right sequence but change the whorl number so you will have 2 whorl 3's or whatever, put a edit note in the comment field for later correction.

If a mistake is made on one whorl and you want to re-enter the data, you do not need to reenter all the whorls on that branch. Enter the correct whorl number and reenter that whorl (leave a note in the comment field to delete the other incorrect data).

You can use arrow keys to move around the current screen and edit data before final "ENTER Y TO CONT".

Avoid using backspace to edit data in a field, type over works fine.

Some fields have default values, to accept data already entered in a field just hit ENTER.
Be careful to typeover all the existing incorrect data in a character field, but for a numeric field just type the number and ENTER (if decimal is 0 it does not need to be entered).

Typing zero over some other number in a 1 wide numeric field causes the field to go blank, The field is NOT blank, the zero did enter it just does not show up (beats me why).

When the screen says "ENTER Y TO CONT" the highlighted box should contain an F. If the data is OK and you want to continue to the next input screen press Y. When the screen asks for a Y or N, there should already be a T or F in the box.
T is the same as Y, F is the same as N.
To answer yes, Y and ENTER. To answer no, N and ENTER. No other input will be accepted. Just ENTER to accept T or F already displayed.

Some numeric fields will only accept data in a preset range. If you enter value outside the range the cursor will not move until it has been corrected. (ie a 9 if the range is 0-5)

Appendix 3-- Instructions for Data Entry from Field Sheet to PC.

Project FOREST Data Entry from Field Data Sheets

This package contains 3 data entry programs for the transfer of FOREST data from completed field data sheets to computer files. The data entry programs display on-screen prompts for the data, create an ASCII/TEXT file, and append the data to it. The programs will work on any IBM PC, XT, AT, laptop, or compatible computer with a mouse. A color monitor is not required but a printer is necessary to print the output data files. A hard drive is not required but the whorl data file will be very large and may not fit on one floppy.

<u>Installing:</u>
Copy the files on the floppy to the hard drive of a PC.
C:\>COPY A:*.* to copy from a floppy in drive A to current directory

<u>Data entry notes:</u>
Data is entered on three separate screens.
Plot data, the data at the top of the data sheet, is entered on the Plot screen. Plot data should have only been collected for new plots.
Tree data, the data on the left side of the data sheet, is entered on the Tree screen.

Whorl data is entered on the Whorl screen.

A data entry screen is started by typing PLOT, TREE, or WHORL depending on which type of data is to be entered.

Enter the TREE data from all the field data sheets first, then go back and enter all the WHORL data.
PLOT data only needs to be entered for new plots.

On a screen, after each prompt, type the data and press <ENTER>.
A help message for each field will appear in the lower left corner.
Use ARROW keys to move around the screen.
If you have a mouse it may also work, just click on a field.
To edit a field use BACKSPACE or type over with correct data.
ENTER to accept data already displayed.

Missing Data: Character fields - leave blank, Numeric fields - Enter -9 if there is room, 0 otherwise.

To continue with the next tree/whorl move to "Continue?", press Y and ENTER.
The data will be saved and the cursor will return to the first prompt. The data fields will still contain the old data, either replace or ENTER to accept unchanged.

To QUIT move to "Continue?"
press N and ENTER.

Data entered will be saved in TREE.DAT, WHORL.DAT, or PLOT.DAT
These are TEXT files that can be edited with any ASCII/TEXT editor.

To print a .DAT file:
C:\>PRINT TREE.DAT <ENTER>

To view a .DAT file on screen:
C:\>TYPE TREE.DAT |MORE

<u>Sending the data in:</u>
Please print and proof-read the data. The files are ASCII/TEXT format and can be edited with any TEXT editor, like EDLIN. Many word processing packages can import TEXT files

(Word Perfect), just remember to save the edited files in TEXT format. If you have no way of editing the files, send the printouts with the corrections marked on it with the floppy.

Copy all the .DAT files to a floppy:

```
C:\>COPY *.DAT A:*.*    (copies all files with a .DAT from current
                        directory to a floppy in drive A)
```

Mail the floppy and copies of the original data sheets to:
Paul Miller
USDA Forest Service Fire Lab
4955 Canyon Crest Drive
Riverside CA 92507